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ABSTRACT

This monograph on sport skill development: (1) raises questions concerning the teaching and learning of sport skills; (2) provides a general information base from which answers may be derived; and (3) identifies teaching strategies which appear to facilitate sport skill learning. The monograph's intent is to raise questions as well as to suggest answers, in order to provide a framework within which physical education teachers can examine sport tasks, learning processes, and teaching techniques. In the introduction, a review of the general approach and content concerning sport skill development discusses the need to re-examine teaching and illustrates the general approach to motor learning. The second chapter focuses on motor tasks and analysis of sport skills, including a review of motor skill taxonomies, and the definition and assessment of motor task skills. The learner and analysis of the learning process is the topic of the third chapter, which discusses an information-processing model, the relation of information processing to performance and learning, and factors influencing information processing ability. The fourth chapter discusses the teacher's role in facilitating skill development. Topics covered include learning stages and teacher responsibilities. (CJ)

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DEVELOPING SPORT SKILLS

A Dynamic Interplay of Task, Learner, and Teacher

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MONOGRAPH 2 MOTOR SKILLS: THEORY INTO PRACTICE

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Monograph 2

MOTOR SKILLS: THEORY INTO PRACTICE

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Chapter One

INTRODUCTION: REVIEW OF THE GENERAL APPROACH AND CONTENT

How effective are we in developing our students' skill in sport? It is not uncommon for a teacher to ask, "Why do my students play the game so poorly? It's as though I hadn't taught them anything. What happened to everything they learned during the first part of the sport unit?" It would seem from conversations with teachers of physical education that we could and should be more effective in facilitating the development of sports skill in our classes. Discussion frequently focuses on questions such as, "How can curricular progression be improved? How can practice drills be structured to best develop skill and maintain student interest?" The answers to these and related questions are not simple; pre-packaged solutions, guaranteed to produce significant change within a five-week teaching unit, are not readily available. As in the case with "tennis elbow," short-term relief from the major symptoms can be achieved relatively easily; however, cure and prevention of the chronic problem may require careful analysis and possible restructuring of techniques. For example, student interest may be temporarily increased by introducing a novel drill during practice. However, the systematic development of skill in sport may require a re-examination of the traditional approach to teaching and a restructuring of procedures for the introduction, practice, and performance of sport skills.

The Need to Re-examine Teaching

Perhaps an illustration will clarify the need for a re-examination of the traditional approach to teaching sport skills. Assume that you have agreed to teach a friend to play backgammon and that the instruction will follow the general procedures and progressions used in physical education classes. You begin by assembling the necessary "equipment" including board, playing pieces, and dice. You arrange the pieces on the board in the proper starting alignment and instruct your friend to be seated and toss the dice. Following the throw, you instruct the student to move two specific playing pieces to two specific points on the board in accord with the values appearing on the dice. It is quite likely that at this point, if not earlier, you would be faced with an uncooperative student and a barrage of questions. "Wait a minute! What is the purpose of the game? How is the winner determined? What is the importance of the initial alignment of pieces and the divisions of the board? What are the options in moves for a given roll of the dice? What are the major strategical issues to be considered?" The questions seem obvious and clearly justified in this example. How could someone possibly learn to play the game of backgammon without an understanding of the essential information requested in the questions. Indeed, it is quite likely that your approach to teaching the game would differ considerably from the example above.

Consider an alternative approach to teaching backgammon. Instruction begins with a brief explanation of the purpose of the game and basic rules of play. You and the learner then play a "practice game" during which response options for each roll of the dice are identified and evaluated, and rules are clarified. Through "coached play" the learner is systematically exposed to the variety of situations arising during a game. Standard moves and elementary strategy are introduced in relation to the evolving game situations. Emphasis is placed on conveying to the learner the "sense of the game." Similarly, advanced techniques and strategy are introduced in subsequent games as the learner develops skill. Clearly, this approach would be the more reasonable choice for teaching a board game such as backgammon.

Sport skills, like board games, combine variable elements of skill, chance, and strategy. However, the traditional approach to teaching sport skills resembles the first, seemingly foolish, approach to teaching backgammon. The sport unit frequently begins with instruction and practice drills on one isolated movement technique without reference to the overall goal of the activity, the purpose of the specific skill, the game situation in which the skill might be used, the options available in performing the skill, or the general strategical framework for the practice. The learner rarely gains an understanding of the "sense of the game" or the relation of the specific movement technique to specific game situations. The teacher not only dictates the opening move and all subsequent moves, but rolls the dice for the learner as well! Although the examples illustrated a somewhat extreme situation, the potential need to re-examine traditional approaches to teaching sport skills seems clear.

Focus of the Monograph

The purpose of this monograph is to raise questions concerning the teaching and learning of sport skills, to provide a general information base from which answers may be derived, and to identify strategies of teaching which appear most likely to facilitate the learning of sport skills. The intent is to raise questions as well as to suggest answers, to provide a framework within which teachers can examine the nature of sport tasks and the process of learning in order to make decisions concerning the most appropriate teaching techniques.

The process of developing skill in sport, of maximizing the degree of success attained by students, requires creative, thoughtful decision-making on the part of the teacher. Decisions must be made relative to curricular progression, specific content for a given activity unit, selection of individual skills to be taught within a particular sport, and length and focus of practice sessions. These decisions may be based on the opinion of the authorities in the field, on tradition, or on common observation and critical analysis. An alternative basis for teacher decisions is knowledge of the skill acquisition process; that is, deciding how to teach based on available information concerning how students learn sport skills.

In the following chapters, information will be presented regarding both the processes involved in the performance of sport tasks and changes occuring in these processes as skill is developed. Based on this information, suggestions will be made for content and direction of teaching techniques. However, specific teaching methods cannot be prescribed for each child and each teacher. In reaching a decision as to specific methodology, each teacher must consider the age and skill level of students, the facilities and time available, and the energy expenditure necessary to carry out particular suggestions. In addition, teachers must evaluate suggestions relative to personal expertise and the teaching style that is most comfortable for them. Only then is the teacher prepared to make both informed and realistic decisions regarding the teaching of sport skills. The information to be presented regarding the learning and teaching of motor skills will, hopefully, provide a useful basis for such teacher decisions.

The concepts to be presented have been drawn from the body of theoretical and research information within the field of motor learning. Motor learning, as an area of study, is a creative synthesis of information drawn from physical education, experimental psychology, bioengineering, neuropsychology, and biomechanics. Motor learning theory cannot dictate precise teaching methodology; it is not a new chapter in a methods text. However, motor learning is a field of scholarly inquiry which provides a wealth of information regarding the requirements for performance of motor skills of various types, the nature of the process of learning motor skills, the characteristics of skilled performance, and the like. As such, information from motor learning can serve as a valuable resource for the teacher.

An Illustration of the General Approach

To illustrate the application of motor learning concepts to the teaching of sport skills, consider as an example the question posed at the beginning of the chapter. *Why* can't students play the game? Because we didn't *teach* them the game. True, during the first four weeks of the field hockey class, for example, the students were taught (and practiced) the dribble, drive, two tackles, two dodges, general offensive and defensive positioning, and rules, and they participated in general conditioning activities. But were they taught the game? Probably not.

The game is not rules or conditioning. The game is not a composite of fundamental skills. The game, indeed, incorporates and/or requires these factors; but they are not the game. The game is a complex, variable interplay among opposing players, involving patterns of action and reaction, within a context of movement of players and objects. The beauty of the game, and the evidence of skill in sport, lies not only in the smoothness and precision of players' movement, but also in the subtle timing, the deception, the quick and accurate adjustments to changing situations. This is the game; this is what we must teach; and what students must learn if they are to become skilled. Identification of factors contributing to skill and sport has been a major focus in the field of motor learning. Several

concepts related to developing skill in sport will be discussed and illustrated in the following section.

Related Concepts for Motor Learning

In attempting to identify factors contributing to the development of skill in sport, three concepts related to human learning seem most relevant. First, we are adaptive organisms (Lorenz, 1969). Second, to be successful, a performer's movements must be matched to the prevailing environmental circumstances (Higgins, 1977). Third, to be a successful games player, the learner should practice in gamelike situations as much as possible (Gentile, 1972; Marteniuk, 1976; Whiting, 1969). Each of these concepts will be briefly elaborated and then examined in terms of its application in the teaching of sport and skills.

We are adaptive organisms, capable of altering our behavior in accord with the circumstances of our environment, based on information regarding the consequences of our behavior. Evidence of the adaptive nature of human behavior is found in literature from the social sciences, physiology, and psychology. An example of adaptive behavior is provided by two individuals engaged in meaningful conversation (Robb, 1972). The key to successful communication lies not in speaking, but in replying. That is, following the initial statement, the individuals *reply* to each other. Based on information from the conversation partner, both verbal and non-verbal, the individual may repeat the message, simplify it, elaborate it, or defend it. The response is adapted to the perceived requirements of the situation; the verbal messages of the participants thus serve both an informational and a feedback function. The concept of statement and reply may also be applied to sport performance.In a fencing bout, the performer must reply to the statement of the opponent, by appropriately parrying the opponent's attack. Indeed, the term *parry* is commonly used to refer to an evasive reply in conversation!

The adaptive nature of human motor behavior is well-documented. Unlike organisms lower on the phylogenetic scale, we are capable of amazing adaptability to the prevailing environmental context in which movement occurs. The learning of motor skills thus involves a modified trial-and-error process. A trial movement is executed, the degree of success or error is evaluated, and the performer subsequently repeats or modifies the movement response, as appropriate. Thus, learning depends upon both environmental information and feedback, and is clearly a process of behavior-adaptation. Indeed, non-adaptive human behavior involving perseveration of an inappropriate response is considered a pathological condition.

The second concept is a specific application of the concept of adaptation. To be successful, movements must be matched to the prevailing environmental circumstances. That is, the range, force, velocity, and timing of movement must be appropriate to (adapted to) the particular performance situation in which the individual is involved. There must be a match between essential characteristics of the movement and of the performance

context. Therefore, skill in sport must involve three types of learning: perceptual, decision, and effector learning.

Perceptual learning involves the ability to recognize and identify critical aspects of the performance situation to which movement must be adapted; for example, the relative position of teammates and opponents. Decision learning has two aspects: (a) the ability to select what appears to be an appropriate response in terms of the analysis of the situation; for example, keep the ball or pass it, and (b) following the response, the ability to evaluate the appropriateness of the response in terms of feedback regarding its outcome; for example, whether or not the pass was intercepted. The third type of learning, effector learning, involves the ability to execute the selected movement pattern in a smooth, efficient, coordinated manner. The result of these three types of learning is the development of adaptive responses, matched to the variety of situations encountered in sport performance.

The final concept states that to be successful in matching movements to sport environments, the learner must practice in a gamelike situation as much as possible. Isolated drills on fundamental game skills may be helpful in the third type of learning, effector learning. Clearly, through guided practice including demonstration, repetition, and feedback, the learner's ability to execute skills such as dribble, pass, and shoot will improve. However, it is unlikely that drills on fundamental skills as traditionally structured will facilitate either perceptual or decision learning.

In order to quickly perceive the requirements and restrictions of a game situation, the learner must first recognize both the similarities and the differences of the situation as compared to other game situations. This requires that the learner be given practice in the variety of situations occurring in game play. The learner cannot be expected to differentiate among performance contexts without systematic exposure to them. In order to make a decision regarding the appropriate response for a particular situation, the learner must be given the opportunity to try out and evaluate movement responses in the respective situations. The learner must be guided to learn not simply a general movement skill such as passing, but also the modifications of the general scheme of movement that will be most effective in terms of the time and positional requirements of particular situations. Finally, the learner must be able to execute the selected response accurately and efficiently. The learner must develop, through systematic practice, a repertoire of related, yet situationally-specific movement responses.

Why can't students play the game? Possibly because they have been taught and have practiced isolated movement responses, the third type of learning, divorced from the concomitant perceptual and decision learning essential to game play. Their motor behavior has developed in response to the conditions of practice which most likely did not include opponents, variabilty in performance situations, or a realistic time press. Adaptive responses were developed, but the movements were matched to unrealistic

performance situations. To learn to play the game, students must practice in game-like situations.

Before discussing one approach to game-like learning, it should be noted that several interacting factors appear to have contributed to the emphasis in physical education on the practice of isolated fundamental skills. First is the assumption that significant positive transfer will occur from the development of isolated skills in practice drills to the application of these skills in the game situation. This assumption is not well-substantiated by research evidence, and motor learning theory argues strongly against it (Marteniuk, 1976; Whiting, 1969). A second factor contributing to extensive drills on fundamentals has been the desire on the part of physical educators to avoid "throwing out the ball" and , thereby, equating physical education with recreational participation. A related factor is the belief that game play represents non-teaching and the subsequent insistence of supervisory personnel that physical education classes be heavily oriented toward structured practice in the form of skill drills. That it is possible for a game situation to constitute a learning environment, rather than simply a recreational situation, is intuitively obvious. Relative to the need for a structured, controlled learning situation, there is nothing inherent in a game-oriented approach to teaching and learning which precludes the existence of a systematically structure learning environment. Indeed, as we shall see, the structure of practice evolves quite naturally from the game itself.

The Mini-Game Method

How can learners be taught the game? The problem for the teacher is to provide a simplified, yet realistic context for learning. The general procedure to be suggested involves initial exposure to the game itself, rather than beginning the unit with practice of one or several component skills. The traditional procedure involving instruction on how to grip the implement, followed by drill on a fundamental skill such as dribbling in field hockey, clearly does not provide a game-related "set" for the learner. In an attempt to simplify learning and provide for practice of requisite game skills, the teacher has eliminated the learner's awareness of where, when, and why the skill might be used in the game. Verbalizing the relationship of the skill to the game is of limited value in this respect. Until an individual experiences the unfolding of a particular situation, a discussion of possible situations and response options is of limited meaning.

A viable alternative is a situationally-oriented approach to teaching and learning involving a repeating cycle of game play, identification of an area of skill deficiency, mini-game practice drills, and application of the skill in game play. A general description of the mini-game procedure is presented below; a more thorough discussion and specific application to the teaching of team sports will be presented in chapter four.

The mini-game approach to teaching sport skills parallels the second approach to teaching backgammon, discussed earlier. Instruction begins with an explanation of the purpose of the game. Next, rules which will govern game play are clearly specified, with particular emphasis on those

related to players' safety. Following the initial explanations, game play begins. As game play continues, one of several game-related "problems" reflecting skill deficiencies soon becomes apparent. The game is stopped and a mini-game drill is conducted to provide controlled practice of the particular skill. The mini-game drill is structured to provide a simplified practice environment while simulating a game situation. Following the mini-game practice, the specific skill is again applied within the game context. Subsequent practice of the same general skill and additional skills also follow the pattern of game play, mini-game drill, and application in the game. The goal for the learner is to adapt movement responses to the demands of a particular situation. Therefore, instruction must focus not only on movement technique, but also on the performance situation, selecting a response, and executing the movement in the appropriate place at the optimum time.

Preview of Subsequent Chapters

In the chapter which follows, a number of the issues raised in the previous examples will be elaborated, in terms of both conceptual background and application to the teaching and learning of sport skills. Three major factors affect the process of learning sport skills: the task, the learner, and the teacher. Isolated discussion of any one factor, without consideration of the interactive nature of all three, would be at best self-limiting. For example, the nature of the teacher's role at a given point in time is directly dependent upon the particular learning process taking place. The nature of the learning process, in turn, depends upon the past experience and present skill level of the learner, and the nature of the particular performance demands. The nature of performance requirements varies as a function of both the type of task and the level of proficiency attained. Therefore, the process of learning skills will be discussed relative to three broad questions: (a) What are the demands placed upon the learner by the particular type of task? (b) How does the learner solve the motor problem; that is what processes are involved in meeting the requirements of the motor task? and (c) How can the teacher facilitate the process of learning to accomplish a particular type of motor task?

Chapter two will focus on the requirements for performance of particular motor skills. Several systems of classifying sport skills will be reviewed and the application of classification systems to curriculum design and selection of perceptual-motor activities will be illustrated. Differences in performance requirements among categories of sport tasks will be identified and implications will be drawn for the respective learning processes.

Chapter three will identify the processes involved as the learner attempts to meet the requirements for performance of sport skills. The learner will be described as an active, problem-solver and the performance of sport skills will be viewed as a series of information-processing tasks. In addition to analyzing the processes involved in performance at a given point in time, changes occurring in the information-processing tasks as learning progresses

will be identified. Comparisons will be made of the processes involved in the learning of different types of sport skills and implications will be drawn relative to the appropriate emphasis in teaching.

Chapter four will examine the role of the teacher as a facilitator of the learning processes for particular sport skills. Teacher responsibilities will be identified for several stages of learning. The mini-game approach to the teaching of sport skills will be elaborated and illustrated. Particular emphasis will be placed on techniques of structuring practice and providing feedback for different types of skills. Conclusions will be drawn relative to strategies of teaching which appear most likely to develop skill in sport.

It is hoped that the information in the subsequent chapters will be useful to physical educators in several ways. Individual differences among readers in knowledge of motor learning principles, expertise in particular sport skills, and interest in selected topics will determine the specific utility of the information. Although the presentation is, by design, general in nature, the examples are intended to illustrate the potential application of the information to the selection of teaching techniques for a variety of specific sport skills. The material on classifying sport tasks may be useful in designing curricula and establishing skill progressions for a particular sport. Some information may simply increase the reader's knowledge of the process of learning sport skills. In addition, the concepts and suggested applications may serve to generate further research, formal or informal, relative to developing skill in sport. In all cases, the suggestions are meant to be systematically tried, evaluated and modified through the expertise of individual teachers.

Chapter Two

THE TASKS: ANALYSIS OF SPORT SKILLS

What are the performance demands placed upon students by the particular type of tasks to be learned? Do different sport skills require different abilities for successful performance? What types of movement tasks should be included within a movement education program? What guidelines exist for the selection of games for elementary school children? Answers to these questions should be based, in part, on information concerning the characteristics of various types of motor tasks. By systematically classifying both basic motor skills and sport skills in terms of specific characteristics and requirements for successful performance, similarities and differences in performance characteristics can be identified across various categories of motor tasks. The information gained through the analysis and classification of motor skills is potentially useful to teachers in several ways.

A system of classifying motor tasks can serve as a check-list for the selection of curricular content. It is not uncommon for movement education programs to consist primarily of balance and basic locomotor activities, with little emphasis on the other categories of tasks such as fine manipulative skills, performed either alone or in combination with locomotor tasks. In designing a comprehensive program in movement exploration, a classification of motor tasks relative to the major biomechanical and developmental characteristics of performance could be used as a guide to insure that the selected "movement problems" included all categories of activities.

The selection of games for elementary school children is frequently based on one of several systems of classifying motor tasks. Both DeSantis and Smith (1969) and Richardson (1951) have produced widely-used systems for classifying movement activities for children. The activity categories include relays, group games, large and small muscle activities, catching skills, running, and the like. Typically, activity units for a specific age group consist of a sample of recommended activities within selected categories. An alternative classification system will be presented later in this chapter in which activities are classified according to the demands of the performance context and the complexity of the required movement.

An analysis of the performance requirements for sport skills can suggest the appropriate teaching emphasis for a particular skill. It would seen that for optimum learning to occur, the general methodology and skill progressions used in teaching a particular sport skill should be congruent with the requirements for successful performance of the skill. For example, success in bowling requires a consistent movement technique within a stable performance context and the ability to use kinesthetic feedback to regulate movement. In contrast, success in soccer requires perceptual skills related to estimating speed, direction, and arrival time of players and ball; decision-making skills relative to rapid response selection and evaluation; and motor skills related to a variety of ball-handling techniques. Analysis of the requirements for successful performance of a specific sport task can provide

a framework for teacher decisions regarding both the content and structure of appropriate practice.

In the remainder of the chapter, several systems for classifying sport skills will be reviewed. Suggestions will be made concerning the use of the systems in designing activity units and skill progressions. The final classification system to be reviewed seems to be the most informative in terms of relevent and critical classifications criteria, and the most useful in terms of facilitating decisions about teaching. Therefore, it will be described in greater detail, and a more extensive illustration of its use in the selection of perceptual-motor activities for children will be presented. In addition, implications will be drawn relative to differences in the learning processes among categories of sport skills. The last section of the chapter will focus on a definition of skill and criteria for assessing skill in motor tasks.

Taxonomies of Motor Skills: A Review

A taxonomy is a system of classifying motor skills in terms of characteristics of the movement involved, characteristics of the environment in which the skill is performed, the purpose of the skill, the type of implement used, and the like. A taxonomy can provide a better understanding of both commonalities and differences among motor skills across several dimensions, and a recognition of requirements, either similar or unique, involved in performance. Many taxonomies of motor skills have been proposed: examples of the major types of taxonomies will be reviewed. In evaluating a classification system for use in designing curricular content, activity progressions, or teaching strategy, the teacher should consider both the particular area of interest and personal expertise, and select or modify a taxonomy accordingly.

Several authors have proposed biomechanical taxonomies of motor skills. Broer (1966) has classified motor skills according to their purpose. Major divisions in the taxonomy include skills involving support (e.g., hanging), motion (e.g., running), moving external objects (e.g., throwing or striking), and reception of force (e.g., catching). Within each category, the specific purpose can be accomplished with a variety of movements. For example, an object can be moved by throwing, striking, pulling, or pushing. Throwing may involve an overarm, underarm, or sidearm movement. The basic skills identified in the taxonomy not only form the foundation for specific sport skills, but also enable the individual to cope efficiently with daily tasks. As suggested earlier this taxonomy could be used in designing either a comprehensive unit in "basic motor skills" or a program in movement exploration. Age-appropriate activities could be selected from each category, with the teaching emphasis on development of variations in the movement technique used to accomplish the basic task.

An alternative biomechanical taxonomy was developed by Logan and McKinney (1970). Motor skills are classified according to the type of joint movement involved in performance. Categories of movement include adduction/abduction, flexion/extension, depression/elevation, circumduc-

tion, and the like. Categories are defined and applied to movement of all body segments. This type of biomechanical taxonomy would appear to be most useful to bioengineers, kinesiologists, and practitioners involved in physical training or rehabilitation.

A very different type of taxonomy was developed by Laban to classify movements used in dance (Dell, 1970). The basis of classification is movement quality along two dimensions: type of exertion (effort) and spatial adaptation (shape). Both dimensions of movement quality include a number of subcategories. For example, effort may be described on a continuum from sustained-to-sudden, light-to-strong, or free-to-bound. Similarly, shape may be classified as rising-sinking, growing-shrinking, or advancing-retreating. Laban's taxonomy combines considerable analytical detail with descriptive categories clearly applicable to dance forms. It would seem that the criteria of performance quality is also of potential use in the design of movement exploration experiences for young children. For example, the effort and shape dimensions of movement quality could be combined with Broer's taxonomy as a basis for designing movement problems. The resultant categories would identify a basic motor task, such as moving the body, as well as a series of variations in the quality of movement used to accomplish the purpose, such as sudden-strong-rising movement or sustained-light-retreating movement. The concept of variations in the shape or spatial adaptation of movement has frequently been employed in movement exploration programs. Children are typically asked to move at various "levels" (e.g., "Make yourself as small as possible as you move across the room"). Similarly, children may be asked to assume a particular shape while stable or moving (e.g., "Make yourself as round as possible"). However, the concept of variations in the force and timing of movement has not been widely used. The addition of Laban's categories of movement quality to Broer's classification of purpose of the skill would provide a basis for systematic introduction of variations in effort, shape, and movement technique for each category of basic skill. The result would seen to be a very comprehensive array of movement tasks.

Konorski (1969) proposed a very simple taxonomy of motor skills based on neurophysiological characteristics of the human neuromuscular system. Motor skills are classified according to their purpose into three categories: locomotor acts (e.g., running), isolated limb movement (e.g., throwing), and postural movement (e.g., standing). Distinct structures and pathways for the neurological control of the three categories of skills have been identified. It appears that control of postural responses is subserved by phylogenetically-older neurological structures. In contrast, isolated limb movement and object manipulation are controlled by "newer", more complex neurological mechanisms. Developmentally, the emergence and refinement of postural responses is followed by the development of basic locomotor skills in which a balanced, upright orientation of the body must be maintained under dynamic conditions. It has been suggested that the neurological control of isolated limb movement is superimposed upon the postural and locomotor control systems. Thus, adequate refinement of the

postural and/or locomotor systems may be a prerequisite for success in tasks involving fine manipulation of objects.

Konorski's classification system has been used by researchers in child development and by theoreticians dealing with issues of motor control. Educators involved in devising program content for elementary physical education have used the taxonomy as a basis for designing skill progressions. Postural activities and basic locomotor skills are typically presented or reviewed during the initial portion of an activity unit. Manipulative skills, such as ball bouncing, are usually introduced later and are performed initially in a standing position. It seems that the basic postural skill of standing is well-developed and will require little conscious control by the child. Thus, the child will be able to focus the majority of attention on the manipulation task. The combination of object manipulation and locomotion represents a more advanced level of motor control. Additional task complexity may be achieved by varying the form of locomotion (e.g., run, slide, or skip) and/or the characteristics of the object (e.g., size, shape, speed, or rebound properties). The concept of systematically increasing the complexity of motor tasks will be discussed further in chapters three and four.

Whiting, Fitts, and Knapp have devised taxonomies of motor skills based primarily on concepts drawn from motor learning. Each of the taxonomies is applicable to the analysis of sport tasks, and examples of the classification of sport skills will be included in the following descriptions. A more complete analysis of sport tasks will be presented later in the chapter following the description of a composite taxonomy.

Whiting (1969) identified three categories of motor tasks involved in the performance of sports skills which utilize a ball or similar object. The first two types of tasks require performance in relation to a moving object: (a) acquisition of a ball in flight (e.g., catching a ball in the hands or with an implement such as a lacrosse stick), and (b) acquisition of a ball in flight followed by directing the ball toward a target (e.g., batting and fielding skills). The final category of tasks includes propelling an already-acquired ball toward a target (e.g., golf drive or soccer corner-kick). The obvious limitation Whiting's classification is an intentional one; the taxonomy was designed to deal exclusively with sport skills involving a ball, shuttlecock, puck, or similar projectile.

A two-dimensional taxonomy of motor skills was developed by Fitts (1962). Motor skills are classified according to the condition of both the performance environment and the performer, prior to the initiation of the movement response. The three categories within Fitts' taxonomy are presented in Figure 2.1. Motor skills in the first category (environment and performer stable) are described as least complex; examples include golf and archery. Skills in the third category (environment and performer moving) are the most complex; examples include a roll-out pass in football and a moving forehand drive in tennis. The middle category includes skills which involve movement of the performer, or movement of objects/people in the environment, but not both; examples include bowling and baseball batting, respectively. The strength of Fitts' taxonomy is that it takes into account

the nature of both the performer and the performance environment. Clearly, these two factors interact to determine the complexity of the sport task in terms of demands on attention, requirements for perceptual analysis and decision-making, and control of movement. In addition, the nature and complexity of the requirements of a given sport skill have direct implications for the structure and focus of practice situation by the teacher. However, the failure to differentiate between the subdivisions of the second category (performer moving or environment moving, but not both), may be a weakness in the classification system. Indeed, the question of what to introduce first to students, movement of environment or movement of performer, is critical to teachers of sport skills.

ENVIRONMENT	BODY	EXAMPLE
FIXED OR STABLE	AT REST	DRIVING A GOLF BALL
STABLE OR MOVING	IN MOTION OR AT REST OR "SET"	BOWLING BASEBALL BATTING
MOVING	IN MOTION	FOOTBALL ROLL-OUT PASS

Figure 2.1. Fitts' Taxonomy of Motor Tasks

Knapp (1963) also developed a taxonomy of motor skills based, in part on characteristics of the performance context. A continuum of motor skills is proposed, ranging from those which are primarily habitual (closed) to those which are primarily perceptual (open). Examples of the classification of several sport skills according to Knapp's concept of a continuum are presented in Figure 2.2. The exact position of a particular motor skill on the continuum is determined by the relative importance of perceptual abilities

and habitual patterns of movement in the perfected skill. The departure from artificially discrete categories of skills is noteworthy. However, it would seem that Knapp has inappropriately employed mixed classification criteria; perception and habituation, although highly dependent factors, are distinctly different characteristics of performance. Perhaps a clearer description of the skills continuum could be achieved by first considering the nature of perceptual processes required for a given skill, and then noting the degree of movement habituation attained.

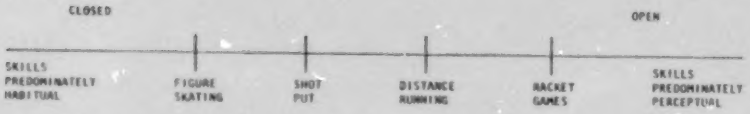

Figure 2 2. Knapp's Continuum of Motor Skills

Despite the limitations discussed above, the taxonomies of Whiting, Fitts, and Knapp have had a significant influence on motor learning theory and research. All three authors were concerned with analyzing the similarities and differences in requirements of various motor tasks, in an attempt to draw implications for the best means of facilitating the learning of skills within the several categories. Both Fitts and Knapp included environmental demands as a critical factor in the analysis of requirements for successful performance of motor skills; the taxonomies were not based solely on the characteristics of the performer's movement. These factors are also incorporated in the final taxonomy to be discussed.

A Composite Taxonomy of Motor Skills

Gentile (Gentile, Higgins, Miller, and Rosen, 1975) has developed a composite taxonomy of motor skills. As in Fitts' taxonomy, the classification of motor skills is based upon a consideration of both the performer and the performance environment. The movement of the performer is categorized relative to the role of the limbs and the degree of total body movement, as suggested by Konorski. The performance context is evaluated along a continuum from closed to open; the continuum is based on the degree of change in environmental conditions during performance and avoids the mixed terminology of Knapp. Thus, motor skills are classified relative to two dimensions of performance: type of movement and

type of environmental context. Gentile's taxonomy will be presented in some detail in the remainder of this section. Each dimension will be considered independently, beginning with the analysis of movement, prior to a presentation of the composite taxonomy. The discussion will focus on a comparative analysis of requirements for skilled performance across categories of tasks.

Analysis of Movement

The spectrum of human movement may be divided into two broad categories of responses: instrumental and reflex. The movement dimension of Gentile's taxonomy is restricted to instrumental, or goal-directed movements, involving forethought on the part of the performer relative to the consequences of the response (Gentile, 1972). Instrumental responses involve the discovery of a means-end relationship; the performer attempts to find a movement pattern (means) that will be successful in terms of the performance goal (end). For example, the performer wants to put the ball through the basket, catch the frisbee, or hit the target. Although the differentiation between reflex and instrumental serves to identify broad groups of motor responses, a clear analysis of learned motor skills requires subdivision of the instrumental category.

Instrumental movements may be of two types: orienting and adaptive (see Figure 2.3). Orienting movements are instrumental responses used to focus or adjust the sensory apparatus to facilitate the reception of information from the external environment (Gentile, 1972). For example, to obtain information regarding the characteristics of a ball in flight, the performer may move the eyes, head, or entire trunk in order to allow light stimuli from the ball to strike the visual receptors in the eyes. The development of efficient, effective orienting movements is essential to the successful performance of sport skills. However, orienting movements are excluded from Gentile's taxonomy of instrumental movements. A separate classification of orienting movements, suggested by Gentile, will be presented in chapter three.

Adaptive movements, the second category of instrumental responses, are movements used to (a) maintain or change the position of the body in space, (b) maintain or change the position of objects in space, or (c) both a and b, concurrently (Gentile, 1972). Thus, adaptive movements (non-reflexive, non-orienting movements) may be classified in terms of the specific performance goal (see Figure 2.3). Responses for which the goal is maintenance of body position are classified as movements involving body stability. The second category of adaptive movements, body transport, includes responses for which the goal is to produce a change in body position. Both body stability and body transport skills may be carried out either in isolation or in combination with limb or object manipulation. That is, some motor tasks involve a single performance goal requiring either body stability (e.g., stand on one foot) or body transport (e.g., run across the gym). Other types of motor tasks involve a secondary goal of limb or object manipulation in addition to the goal of either maintaining or changing body

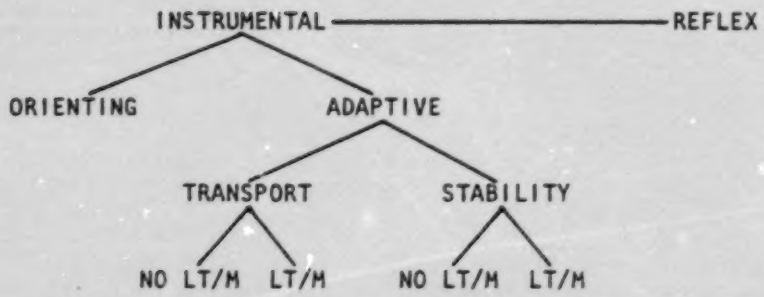

Figure 2.3. Gentile's Taxonomy of Human Movement

position. For example, the task of clapping the hands as fast as possible while standing on one foot involves a secondary goal of limb manipulation in addition to the goal of maintaining body stability. Similarly, running and dribbling a ball requires the performer to accomplish two goals concurrently, body transport and object manipulation. Therefore, the role of limb manipulation is classified within both the stability and transport categories as follows: absence of a secondary limb transport/object manipulation goal (No LT/M) and presence of a secondary limb transport/object manipulation goal (LT/M).

Although possibly confusing at first reading, the subclassification of adaptive movements relative to the presence or absence of a secondary manipulation task is critical to a full understanding of the performance demands for various motor skills. In contrast to organisms lower on the phylogenetic scale, the ability of humans to use the lower limbs for transport and stability frees the upper limbs for object manipulation. This independent use of the upper limbs greatly expands our capabilities for environmental exploration and subsequent adaptation of movement responses. In addition, assessing the extent to which a child is able to perform two tasks simultaneously may be a valuable index of skill development; this topic will be pursued further in chapter three.

To summarize, the first dimension of Gentile's taxonomy identifies the type of adaptive movement involved in goal-directed performance. Motor tasks are classified relative to (a) the primary goal of performance (maintaining a stable position or changing the body position) and (b) the presence or absence of secondary limb or object manipulation. Examples of motor skills within each of the four categories of the movement dimension are presented in Figure 2.4.

Analysis of Environment

The second dimension of Gentile's taxonomy (Gentile et. al., 1975) analyzes the environment in which instrumental, or goal-directed, motor

NATURE OF MOVEMENT

BODY STABILITY		BODY TRANSPORT	
NO LT/M	LT/M	NO LT/M	LT/M
HEADSTAND	ARCHERY	RUN	RUN AND THROW JAVELIN

Figure 2.4. Gentile's Taxonomy of Motor Tasks: Movement Dimension

tasks are performed. Once the goal of a particular response is identified, certain events in the performance environment become regulatory in that they define the characteristics of the pattern of movement that will be successful in goal-attainment (Gentile, 1972). That is, the movement response must be organized in such a way that the characteristics of the movement match the regulatory characteristics or constraints, of the environment (Higgins, 1977). For example, the position of an object in space (such as a target) dictates the direction in which movement must occur; the size of the object to be manipulated dictates the appropriate type of grasp; the weight of an object specifies how much force must be exerted to lift it; the temporal characteristics of an object dictate when to move if interception is to occur; the spatial/temporal characteristics of an object specify when and where to move (for example, in catching a ball the performer must be at the right place, at the right time to be successful); the spatial/temporal characteristics, the size, and the weight of an object dictate when and where and how to move (consider the differences in the characteristics of the movement used in catching a thrown shuttlecock and catching a thrown medicine ball).

In batting a pitched ball, the performer is not free to arbitrarily choose when and how to swing; the swing must occur neither too soon nor too late and must be neither too high nor too low. The characteristics of an effective swing are determined by the flight speed and direction of the ball; that is, by environment. The task for the learner is to first accurately assess the characteristics of the performance environment, and then organize the movement response so that the spatial and temporal characteristics of the movement match the characteristics or constraints of the environment.

Gentile (1972) has classified adaptive motor skills along a continuum relative to the regulatory environmental conditions under which

performance takes place. When the environment is stable, or there is little likelihood of change in the nature of environmental constraints during performance, the situation is under spatial control. The performer must match the positional and directional characteristics of the movement response to the spatial characteristics of the environment. However, the performer is free to independently organize temporal characteristics of the response such as start, finish, and duration, without the necessity of reference to environmental events. Motor skills performed under spatial control are called closed skills. Examples of closed sport skills include bowling, golf, and gymnastics. In each case, the environmental characteristics remain stable during a given performance trial and decisions regarding the initiation and duration of movement are left to the performer's discretion.

When the performance environment is characterized by change or movement of objects or people, and when this change is directly related to the movement goal, the situation is under spatial/temporal control. The performer must match both the spatial and temporal characteristics of of the movement response to the characteristics of the environment. Motor skills performed under spatial and temporal control are called open skills. Sport skills such as heading a soccer ball, catching a softball, and tackling a ball-carrier in football are examples of open skills. In each case, both the spatial characteristics and the timing of a successful movement are dictated by the characteristics of the moving object or person in the environment.

For the purpose of classification, this continuum of environmental conditions has been artificially dichotomized into two categories of environmental constraints, spatial and spatial/temporal, to form the second dimension of Gentile's taxonomy. The composite taxonomy and examples of motor skills within each of the eight categories are presented in Figure 2.5. Correct classification of a sport skill requires an analysis of three aspects of performance: (a) does performance involve maintaining a stable position (body transport), (b) does performance involve a secondary manipulation of limbs or object (no LT/M vs LT/M) and (c) does performance occur under spatial contraints (closed skill) or spatial/temporal constraints (open skill)? In classifying the skill of a running javelin throw, the answers to the above questions are "body transport, object manipulation, and spatial constraints," respectively. Therefore the skill is placed in the upper-right category in Figure 2.5.

Classification of Sport Skills

A comparison of requirements for skilled performance of several motor tasks may serve to illustrate the application of this classification system to the analysis of sport skills. Although the lower limbs generally carry-out the stability/transport aspect of performance, and the upper limbs execute manipulation tasks, this is not always the case. The handstand is a skill requiring maintenance of body stability with no secondary limb manipulation, performed in a spatially constrained environment. In this skill, the upper limbs are not involved in LT/M, but rather carry out the primary body stability function, normally performed by the lower limbs. In the

NATURE OF MOVEMENT

NATURE OF ENVIRONMENT	Body Stability		Body Transport	
	No LT/M	LT/M	No LT/M	LT/M
S	Stand on Balance Beam Headstand	Archery BB Free Throw	Run Cartwheel	Run and Throw Javelin Pole Vault
S/T	Balance on Bongo Board	Skeet Shooting	Center in Dodge Ball	Moving Forehand Drive in Tennis Roll-out Pass in FB Fastbreak in BB

Figure 2.5. Gentile's Two-Dimensional Taxonomy of Motor Tasks

cartwheel (body transport, No LT/M, spatial constraints), both the upper and lower limbs are involved in body transport. Running, in contrast, is performed exclusively by the lower limbs, freeing the upper limbs for manipulation of an object such as a ball or javelin. Still different performance requirements are presented by the game of soccer in which both body transport and object manipulation are performed by the lower limbs. The team sports of football, soccer, hockey, and basketball are classified as skills involving body transport and limb or object manipulation, performed in an environment of both spatial and temporal constraints (open skills). However, a subskill of basketball, free-throw shooting, is classified as a closed skill, occuring under exclusively spatial constraints. Although skilled basketball players must develop the ability to successfully execute both free-throws and field-goals, it is not uncommon to observe considerable disparity in a player's performance under the two types of environmental constraints.

Relative to the nature of environmental constraints on performance, some motor skills occupy a variable position along the continuum, dependent upon the skill level of the performer. This situation prevails whenever

the performer causes the movement of an environmental object to which subsequent body and limb movement must conform; examples include the ball toss for a tennis serve and the initiation of movement of a speed punching bag. The relative position of the tennis serve on the continuum of environmental contraints depends upon the predictability of the ball toss which, in turn, depends upon the skill level of the performer. In this case, although the tennis serve is an open skill (the ball is moving), the performer can control the requirements for the movement response (racket swing) to the extent that the nature of change in the environment (characteristics of ball toss) can be controlled. For a highly skilled tennis player, the variability in the placement of the ball toss for a specific type of serve is very small. Thus, the advanced player can pre-plan the spatial and temporal characteristics of the racket swing for for the serve, since the characteristics of the ball toss have become predictable. In contrast, the beginning tennis player must adapt the spatial and temporal characteristics of the racket swing to constantly-changing environmental characteristics, due to inconsistency in the placement of the ball toss for the serve.

Activities such as the tennis serve, in which the performer exerts control over spatial/temporal characteristics of the environment, are called self-paced skills (Robb, 1972). In contrast, activities such as the tennis forehand drive, in which the environmental constraints are not subject to direct control by the performer, are called externally-paced skills. It should be noted, however, that as skill in externally-paced activities increases, the performer may gain indirect control over environmental events. For example, in tennis game the response of the opponent becomes the environmental stimulus to which the performer's movement response must be matched. The ability to "set up" the opponent in tennis limits the possible responses to which the performer must subsequently react and, thereby, constitutes indirect control over environmental characteristics.

Closed vs. Open Skills

The nature of the performance environment, by virtue of its regulatory function, determines the nature of the successful pattern of movement that will be developed as a result of practice of a particular motor task (Gentile, 1972). If a motor skill is performed within a constant environment, performance is constrained by a single set of environmental conditions. The learner will organize a single pattern of movement and will develop a consistent movement response with practice. In acquiring skill in target archery, for example, the learner strives to develop a single, fixed pattern of movement in order to match flight characteristics of the arrow to the stable spatial characteristics of the target. Indeed, the learner is instructed to position the body in a consistent location on the shooting line, draw to a consistent anchor point, employ a consistent point of aim, refrain from moving the feet while reaching for successive arrows from the ground quiver, return to the same starting position for each end, and the like. Successful performance of a classical closed skill, characterized by a single,

stable environmental context, requires development of a highly consistent pattern of movement (Higgins & Spaeth, 1972).

If a motor skill is performed within a variable or classical open environment, performance is constrained by more than one set of environmental conditions. The learner will, of necessity, organize a number of distinct patterns of movement in order to adapt to changes occurring in the performance context from trial to trial (Gentile,1972). With practice, the performer will develop a repertoire of movement patterns matched to the specific characteristics of the variable environmental situations under which performance occurs (Spaeth-Arnold, 1976). That is, in open skill performance, the learner must appropriately vary the particular parameters of movement which correspond to aspects of critical change in the environment. In acquiring skill in tennis, the learner strives to develop a diversification of movement patterns in order to successfully match the characteristics of the swing to the variety of ball presentations which will be encountered. Each combination of ball placement, speed, spin, and opponent's position constitutes a unique environmental situation, the characteristics of which must be matched by the characteristics of the movement patterns employed. Not only must the learner develop, for example, both baseline and net shots, forehand as well as backhand, but the learner must also acquire the ability to make subtle alterations in each general type of shot in accord with the specific requirements of each situation which occurs during game play. Clearly, successful performance of an open activity,characterized by a variable environmental context, requires development of a number of diversified patterns of movement.

The differences in successful performance of closed and open skills are critical factors to be considered when planning instructional techniques. In the performance of a classical closed skill, the environment is predictable, since it remains fixed over successive performance trials. Therefore, with practice, the need for monitoring of the environment approaches zero. That is, once the learner has perceived the necessary spatial characteristics of the environment, there is no need for further monitoring. Closed skill performance is self-paced; the learner is free to independently determine the speed, rhythm, and temporal sequencing of the movement. Finally, with practice, the movement pattern for a closed skill becomes fixed.

In the performance of an open skill, the environment is less predictable, since it is changing over successive performance trials. Therefore, constant monitoring of the environment is required by the learner. Indeed, an important result of practice is increased ability to quickly monitor the environment, pick up relevent cues, and interpret the changing situation. Open skill performance is typically externally-paced; the temporal characteristics of the movement must conform to the temporal characteristics of objects and people moving within the environment. Finally, with practice, the movement pattern for an open skill diversifies. The learner develops a repertoire of movement patterns matched to the particular assortment of environmental conditions under which performance takes place.

Classification of Activities for Children

Gentile's taxonomy of motor skills may be used to analyze the requirements for performance of traditional games and activities for children. The classification of activities for children requires answers to the same questions posed earlier relative to sport skills: (a) does the activity involve body stability or body transport, (b) is a secondary manipulation task required, and (c) does performance take place under spatial or spatial/temporal constraints? In addition, it is useful to evaluate several corollary issues raised earlier, including the requirements for environmental monitoring and the type of pacing involved in performance.

Examples of traditional activities for children within each of the eight categories of Gentile's taxonomy are presented in Figure 2.6. An evaluation and comparison of the requirements for performance of the sample activities may serve to illustrate the application of the taxonomy to the analysis, selection, and design of movement experiences for children. Activities which would most likely constitute separate categories in traditional systems of classifying activities for children, may fall within the same category in the present taxonomy. For example, "games of low organization" such as Drop the Handkerchief and Cross the Brook, and "gymnastics stunts" such as a cartwheel, occupy the same category. Many of the traditional activities for children are open skills requiring body transport, both in isolation and in combination with limb or object manipulation (see the two, lower-right categories in Figure 2.6). Fewer traditional activities for children are classified as closed skills requiring secondary limb or object manipulation in combination with either body stability or body transport. It is possible that the need to systematically add complexity in the manipulative requirements of tasks has not received sufficient attention in the design of activity programs. Extremely few activities require the maintenance of body stability, with or without object manipulation, in an open environment. An example of a task requiring a child to maintain stability under changing environmental conditions is balancing on a bongo board. In the task of throwing at a moving target the spatial/temporal constraints of the environment are imposed on the organization of the object manipulation aspect of performance, rather than on the body stability function. It seems clear that there is a need for creative design of additional movement activities within these last two categories of motor tasks.

Gentile's taxonomy seems to include the most relevant and critical criteria for classification of motor skills. The two-dimensional structure of the taxonomy provides for analysis not only of the type and complexity of movement required by a task, but also of the type of environmental constraints imposed on performance. It would seem that this composite taxonomy could be a valuable tool in the selection and design of comprehensive movement experiences for children.

NATURE OF ENVIRONMENT	NATURE OF MOVEMENT: Body Stability — No LT/M	Body Stability — LT/M	Body Transport — No LT/M	Body Transport — LT/M
S	Balance Beam Skills Pyramids	Throw at Target Tee Softball	Cartwheel Crossing the Brook Drop the Handkerchief	Run and Bounce Ball Skip and Clap Hands
S/T	Balance on Bongo Board	Toss and Catch Throw at Moving Target	Dodge Ball Jump the Shot Rope Skipping "It" in Tag	Spud Kickball Indian Ball "Chaser" in Tag

Figure 2.6. Gentile's Taxonomy of Motor Tasks Applied to Activities for Children

Defining and Assessing Skill in Motor Tasks

The word skill is used in at least two different ways within the context of learning and performance of motor tasks. Frequently the word skill is used to denote the act or task which is performed, such as the skill of basketball dribbling or a series of swimming skills. Throughout this chapter and the preceding one, reference has been made to sport skills, basic motor skills, and the like. Often the adjective "perceptual-motor" is used or implied when skills are discussed.

The second use of the word skill is qualitative, to describe the way in which an activity is performed. Expressions such as "low skill level" or "exhibiting improved skill" refer to the level of proficiency attained in the performance of a motor task. The remainder of this section will focus on the qualitative use of the word skill.

Although the development and evaluation of skill is a central concern in physical education, there is little agreement on the definition of skill. Some of the differences in definition stem from the compound nature of skilled performance. It appears that there are two aspects of skilled performance: (a) the result of the movement (degree of goal-attainment) and (b) the movement itself (coordination, timing, efficiency, and the like) (Higgins and Spaeth, 1972). Knapp (1964) included both aspects of performance in defining skill as the ability to bring about a predetermined result with maximum certainty and a minimum expenditure of energy. However, in discussing learning, or the acquisition of skill, Robb (1972) defined skill in terms of the accomplishment of a motor task (outcome), without reference to the quality of the movement.

For the entire continuum of motor skills, from the extremes of open to closed, it seems most appropriate to define skill as consistent attainment of the goal of the motor task (Spaeth, 1972). If the goal of the the performer is to be coincident with a moving object as in catching a fly ball, then the performer's skill depends not upon the "form" of the movement, but upon the degree of success at being coincident with the object. If the performer's goal is to execute a forward one and one-half somersault in the tuck position, adhering to standards of competitive diving, then skill is totally dependent upon the pattern of movement produced by the performer. In order to assess the degree of skill exhibited by a performer it is, therefore, essential that the goal of the activity be clearly identified.

Within the category of closed skills, Knapp (1963) defined a subclassification of skills for which the goal is to produce a particular pattern of movement which is technically correct. Diving and gymnastics are examples of this type of skill for which goal achievement is not judged by the result of the movement, but rather by the nature of the movement itself. The form of the movement is of prime importance and actually constitutes the goal for the performer. In contrast, the goal of most open and closed skills is to produce a particular outcome, rather than to exhibit a particular technique. This distinction is an important one, and further clarification may be gained by considering several examples.

While the movement goal for a figure skater may be to exhibit a specific, indeed a specified movement, the same is not true for the majority of motor skills. If a field hockey player demonstrates "ideal form" in stickwork and cannot react successfully to both teammates and opposition during the game, the player is not successful (skilled) in terms of the goal of the game. The same can be said of performance of closed skills. If a bowler adheres perfectly to an imposed technique of bowling and cannot score over 100, the goal of the activity has not been achieved. Earlier it was stated that skilled performance of closed tasks was characterized by a fixed, stereotyped sequence of movement. However, the consistency in performance is in terms of an individualized sequence of movement which leads to successful goal-attainment for the particular performer.

For both open and closed skills, consistent execution of an imposed form, no matter how "ideal" the form may be for other performers, cannot

be described as successful performance if it is accompanied by continual failure at goal attainment. Consider the instance in which a student executes a prescribed technique of movement relatively well, but misses the basket, hits over the baseline or drops the ball. Unfortunately it is not uncommon in this case for a teacher to comment: "Oh, too bad, Mary. You did it just right that time. Tough luck. Keep trying." By adhering to the "ideal form" myth, the teacher has created a potential credibility gap. The student knows that performance was not "just right," since the goal was not attained, the points were not scored. Moving in a particular way is an index of success only in those activities for which the goal is to exhibit a specified technique. In all other skills, the characteristics of the movement must be matched to the particular characteristics of the performance environment, within the general constraints imposed by the biomechanics of the activity and the morphology of the individual (Higgins, 1977).

If skill is defined as consistent goal-attainment, then assessment of the degree of skill exhibited by a performer must be made with direct reference to the goal of the activity. For example, in diving, skilled performance is reflected in consistent reproduction of the specified movement form. In archery, skilled performance involves consistent accuracy in outcome; that is, clustering of the arrows in or near the center of the target. In evaluating skill in activities for which the goal is to produce a consistent outcome, the specific nature of the outcome must be clearly identified. The goal of performance may be speed (e.g., swimming), accuracy (e.g., bowling), distance (e.g., shot put), speed and accuracy (e.g., softball pitch) and so forth. The measurement and evaluation techniques used to assess skill must be valid indicators of the particular performance goal. For many sport skills, the goal of the activity is diversity in responses (e.g., successfully returning a variety of tennis shots). For these activities, appropriate assessment of skill would seem to involve observing the outcome of performance in a variable environment, rather than evaluating the technique of movement while hitting one type of projected ball or the speed and control of movement in repeated volleying against a wall. There is currently an increased emphasis on stating performance goals for motor skills in the form of behavioral objectives and specifying, at the beginning of the sport or activity unit, the performance standards upon which evaluation will be based. It is suggested that the appropriate referent for the content of behavioral objectives is the true performance goal of the particular activity or sport skill.

Summary

A taxonomy of motor skills by Gentile was reviewed in an attempt to identify the demands placed upon the learner by different types of motor tasks. The nature of the environment and the type of movement required for goal-attainment, interact to define the unique performance specifications of a particular motor task. Performance differences between open and closed tasks were reviewed, and the role of body stability/body transport functions, in isolation and in combination with limb and object manipula-

tion, was analyzed for both sport skills and activities for children. Skill in motor tasks was defined as consistent goal-attainment, and differences in the appropriate indices of skilled performance for different types of sport skills were discussed. If, indeed, categories of motor tasks differ in their requirements for successful performance, then it would seem that the respective learning processes would also differ. The next chapter will examine the learner and the processes involved in the learning of motor skills.

Chapter Three

THE LEARNER: ANALYSIS OF THE LEARNING PROCESS

What processes are involved in meeting the performance requirements of a particular sport skill? How does the learner solve a motor problem such as executing a movement so that its completion coincides with the arrival of a moving object? Are there differences among sport skills in the processes involved in learning? What guidelines exist for identifying the specific aspect of unsuccessful performance which requires correction? Answers to these questions can be useful to the teacher in determining the focus of instruction and in identifying the source of performance errors.

Identification of the probable cause of performance failure can be facilitated by a systematic analysis of the component processes involved in performance of the particular motor skill. Consider, for example, the problem of determining why a student is unable to hit a pitched baseball. One possible cause of failure may be incorrect batting technique. The specific error could be an inappropriate stance, a non-level swing, an incomplete weight-shift, a lack of complete arm extension, or a failure to "snap the wrists through the ball." It is also possible that the basic mechanics of the swing are satisfactory, but the timing of the swing is inappropriate. However, simply identifying the error as "swinging late" does not specify the source of the error. Completing the swing too late relative to the arrival of the ball may be due to incorrect judgement of ball speed, excessive delay in deciding whether or not to swing, or inaccurate estimation of the time needed to execute the swing. Each of these possible sources of timing error can be further subdivided. For example, incorrect judgement of ball speed could result from ineffective visual tracking skills, misinterpretation of preliminary cues from the pitcher's windup, or incorrect analysis of velocity cues from the ball. The question of why the performer cannot hit the ball raises many subsequent questions dealing with the relative success or failure of the performer in executing one or more of the component aspects of performance. To successfully hit a pitched ball, the performer must be skilled in a number of perceptual, decision, and motor components of performance. Identification of the probable cause of failure in a particular sport skill requires a systematic evaluation of the extent to which each of the component processes of performance was successfully executed.

Analysis of the processes involved in the learning and performance of various types of motor skills can serve as a basis for determining the appropriate emphasis in teaching different types of activities. The differences in requirements for successful performance of closed and open skills, discussed in the previous chapter, are reflected in the nature of the respective learning processes. For closed skills, such as archery, learning involves the development of an effective pattern of movement, within the spatial constraints of the stable performance environment. The performer must develop the ability to monitor and evaluate kinesthetic/proprioceptive feedback concerning characteristics of the response in order to correct and

control the execution of a consistent pattern of movement. As learning progresses, the performer attempts to progressively narrow the range of variability in the movement response, thereby increasing the frequency of goal-attainment. For open skills, such as basketball, learning involves the development of a diversity of movement patterns, matched to the variety of spatial/temporal constraints within the performance environment. The performer must develop the ability to monitor and evaluate kinesthetic/proprioceptive feedback concerning characteristics of the response in order to correct and control the execution of a consistent pattern of movement. As learning progresses, the performer attempts to progressively narrow the range of variability in the movement response, thereby increasing the frequency of goal-attainment. For open skills, such as basketball, learning involves the development of a diversity of movement patterns, matched to the variety of spatial/temporal constraints within the performance environment. The performer must develop the ability to monitor and evaluate the environmental situation, identify response options, and select the most appropriate response for the particular situation. As learning progresses, the performer attempts to achieve a *movement-environment* match under each of the situations encountered in game play, thereby increasing the frequency of goal-attainment. The emphasis of teaching and the structure of practice must provide opportunities for the learner to develop skill in *all* of the appropriate processes involved in performance of the particular motor tasks.

In this chapter, component processes involved in the performance of sport skills are described as a series of information-processing tasks. Changes occurring in the information-processing tasks as learning progresses are identified. Comparisons are made of the information-processing tasks involved in the learning and performance of different categories of sport skills and general implications will be drawn for the appropriate emphasis in teaching various types of motor activities. In the final section of the chapter, factors limiting the performer's ability to process information are examined.

An Information-Processing Model

In analyzing the processes involved in the performance and learning of motor skills, it is useful to describe the learner as an active, problem-solving, decision-making, processor of information. In this context, the performance of motor skills may be described as a series of information-processing tasks. Consider again the processes required in attempting to hit a pitched ball. The general task for the batter is to evaluate the environmental situation, select an appropriate response, and execute the movement so that the swing coincides with the arrival of the ball. The specific information-processing tasks include focusing attention on the pitcher and ball, analyzing the type of pitch, and deciding whether or not to swing. If the batter decides to swing, the specific movement must be planned, coordinated, and executed. Following the swing, feedback about the movement

must be used to evaluate the effectiveness of the response, and the results of the evaluation must be stored in memory for use in similar situations in the future. Successful performance depends upon the ability of the performer to successfully carry out each of the component information-processing tasks.

Basic Elements

A system for information-processing is comprised of three basic elements: input, central processing, and output (Whiting, 1969) (see Figure 3.1). In the human nervous system, the peripheral auditory, visual, tactual, proprioceptive, and olfactory structures receive stimuli from the environment, providing sensory input to the system. The central nervous system processes the input information; this central processing may include coding, consolidation, comparison, prediction, and the like. Subsequently, the neuromuscular system executes a movement response, constituting the motor output of the system. If the information-processing has been accurate and efficient, the resultant movement response will be matched to the demands of the performance environment.

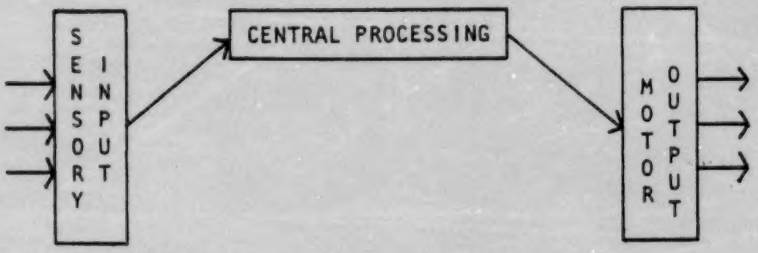

Figure 3.1 Basic Information-Processing Model

In general, information-processing consists of the following sequence of events: picking up information from the environment (input), processing of the information by the central nervous system, and executing a movement response (output). The following discussion of the nature of information-processing in sport skills begins with a consideration of specific tasks involved in the central processing of information.

Within the information-processing system, the central nervous functions as a central processing channel. It is generally assumed that the central channel has a limited capacity relative to the amount of information it can process at one time. An understanding of both the capacity and function of the central channel requires a more detailed analysis of this element of the information-processing system. Welford (1960) suggested that the central channel operates not as a single unit, but rather as a three-link chain (see

Figure 3.2). Within the central processing system, a perceptual mechanism provides for stimulus analysis: an evaluation of the current situation and/or a prediction of a future situation based on successive sampling of environmental stimuli. For example, in batting a baseball, the perceptual mechanism must determine the type of pitch (fast ball, curve, and so forth), the velocity of the pitch and the predicted location and arrival-time of the ball at the plate. Following the analysis of the situation, a translation mechanism provides for general decision-making: determination of the overall logic and direction of the response. Based on information from the perceptual mechanism (and an analysis of the current game situation), the decision mechanism must determine whether or not to swing and, if so, whether to bunt, hit away, and the like. Subsequently, a central effector mechanism provides for movement organization: the coordination and phasing of the muscular activity involved in the response. In batting a baseball, the effector mechanism must organize the components of the swing including force, velocity, timing, and spatial characteristics, and send the appropriate commands to the muscles. Stated differently, the perceptual mechanism provides an answer to the question, "What's going on?" Subsequently, the translation mechanism deals with the question, "What to do?" Finally, the effector mechanism answers the question, "How to do it?"

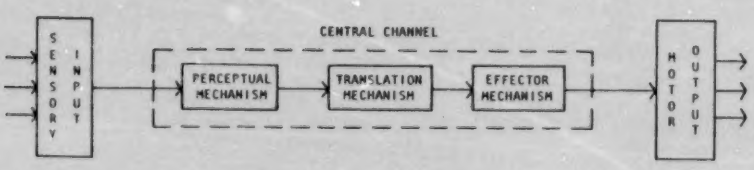

Figure 3.2 Information-Processing Model: Welford's Central Mechanisms

Although input information must be processed sequentially within the system, Welford's (1969) conceptualization of a three-component central channel suggests that two or more quanta of information may be acted upon simultaneously by different central mechanisms. For example, a given quantum of sensory information can be received and analyzed (perceptual mechanism) while a previous stimulus is being acted upon (effector mechanism). While moving to the right to field a ground ball, the first baseman can analyze input relative to the movement of the baserunner going from first to second base. Overlap may also occur between selection of a second response (translation mechanism) and execution of a response to a previous stimulus. While moving to step on first base to put the batter

out, the first baseman can decide whether to subsequently hold the ball or throw to second base. Essentially, the concept of a three-component channel expands the capacity of the central processing unit. The limit on information load is relative to the processing capacity of each of the three central mechanisms.

Perceptual Mechanism/Stimulus Analysis

The perceptual mechanism identifies and integrates sensory input. Information concerning the evaluation of the environmental situation is passed on to the translation mechanism where it is used to determine the immediate plan of action. Information from the perceptual mechanism is also stored in memory for use in future analysis and prediction of environmental events. Perceptual processes depend on past experiences. The identification and interpretation of stimuli is based on a comparison between current input and a representation of the same or similar input in memory. The extent and type of previous experience in related situations determines the perceptual framework of the individual performer. The nature of the perceptual framework is reflected in the efficiency and accuracy with which stimuli are identified and interpreted in a particular situation.

In open skills, the performer must analyze both the spatial and temporal characteristics of an environment in motion. Due to inherent time lags in the information-processing system, the performer must analyze current environmental stimuli and extrapolate from that information to predict the future state of the performance environment (Gentile, 1972). If prediction does not occur, the performer, like an infant attempting to "capture" a rolling ball, will continually respond late to environmental events. Both spatial and temporal characteristics of the performance context must be predicted simultaneously. The more irregular the pattern of the moving object, the more difficult the prediction. Conversely, as spatial and temporal changes become more predictable, the task becomes easier. In both the tennis serve and the basketball dribble, the predictability of the environment increases as ball-control increases; the task literally becomes easier with increased skill.

The perceptual mechanism plays an important role in the successful performance of open skills such as tennis. The performer must monitor the action of the opponent and track the ball in flight after it is hit. Based on the analysis of the extracted information, the player must predict when and where the ball will land and when and where to initiate the swing to return the ball. The speed of the ball in relation to the size of the court imposes a time stress on the processing of information and subsequent response. The critical sensory information must be received and analyzed quickly in order for the player to decide on a plan of action, move to the ball, and complete the swing at the optimum time. The ability to predict the actions of the opponent and to anticipate the flight path of the ball is essential to quick and accurate perception of environmental events. Information concerning the opponent's movement prior to ball contact can be used to predict the

type of stroke that will be hit and the subsequent flight characteristics of the ball. This ability to recognize patterns of activity and predict the subsequent outcome depends upon past experience.

In closed skills the performer must analyze the spatial characteristics of a stable environment. The performer can predict with certainty that stimuli in the environment will remain stationary during performance. In addition, there is no time stress on perceiving environmental characteristics and deciding on a plan of action. In a closed skill such as golf, the performer must analyze the environmental constraints imposed on performance by the distance and direction of the green, traps, rough, and the like. There is no time stress on the perceptual analysis and since the environment is stable, there is no need for further environmental monitoring once the analysis of spatial characteristics is completed. However, the performer must continuously monitor stimuli from the "internal environment", both prior to and during performance. The kinesthetic, proprioceptive, and vestibular systems provide information to the performer concerning the relative position of the body, limbs, and club as well as the force, velocity, and direction of movement. This information must be analyzed and compared with a "mental model" of the desired pattern of movement. The task for the golfer is to attempt to duplicate the successful pattern of movement for the particular situation The ability to accurately monitor and interpret information from the internal environment is essential to the successful performance of closed skills. For both open and closed skills, the perceptual mechanism also functions in the analysis of feedback information concerning the execution and outcome of the movement response.

Translation Mechanism/ Decision-Making

Based on an analysis of the environmental situation, the translation mechanism decides on a plan of action. The decision may be to take one of a number of possible actions or to take no action. The translation mechanism selects, from memory stores, an appropriate plan to meet the demands of the particular situation (Miller, Galanter, and Pribram, 1960). The plan of action constitutes the "blue print" for the subsequent movement response.

In the open skill of tennis, once the player has analyzed or anticipated where and when opponent's return will land, a decision must be made regarding how to hit the ball. Many possible actions could be taken on each stroke, and the skilled player has a large number of previously-learned plans from which one must be selected. The plan of action which is selected must correspond not only to the characteristics of the ball, but also to the immediate performance goal (e.g., win the point on this shot, gain time to recover position, set-up the opponent for a subsequent winning shot, and the like). Thus, the performer must decide what type of stroke to use (e.g. drive, volley, lob, smash, and so on), where in the opponent's court to direct the shot, and what modifications must be made in the general stroke to meet the specific constraints imposed by the approaching ball. These decisions are all dependent on information from the perceptual

mechanism concerning the position and movement of opponent and ball. Due to the time stress on performance of open skills such as tennis, decisions and responses must be made quickly and accurately if performance is to be successful.

For closed skills such as the golf drive, once the performer has analyzed spatial characteristics of the environment, an appropriate response must be selected. In contrast to open skills, closed skill performance involves fewer alternative plans of action. However, the plan of action which is selected must correspond to the spatial characteristics of the course (e.g., length of hole, presence or absence of a dog-leg, location of trees and traps, and the like) and to the immediate performance goal (e.g., maximum distance vs. setting-up a "safer" approach shot). The performer must decide what type of shot to hit (e.g., straightaway, deliberate slice or hook, and the like) and what modifications in the general shot are necessary to meet the specific constraints of the particular hole (e.g., use of wood or an iron from the tee). Since there is no inherent time stress on the performance of closed skills, the performer may contemplate her/his decision for some time. It is not uncommon for a golfer to refer to notes on course yardage, consult with the caddie, and evaluate the relative effectiveness of the choices of previous players, prior to reaching a decision on a plan of action for a particular shot.

The process of decision-making takes time, and in some cases may account for a major portion of the total information-processing time (Marteniuk, 1976). The central processing channel has a fixed capacity relative to the amount of information that can be processed per unit of time. Thus, a performer who is faced with a large amount of information may take a long time to respond. Conversely, if the amount of information to the central channel is reduced, the time required to reach a decision is also reduced. Open skills differ from closed skills in the time available for decision-making. In addition, in an open skill, the performer must process a relatively larger amount of information due to uncertainty concerning which of many possible events may occur in the variable environment. The skilled performer is able to reduce decision time through anticipation of environmental events.

Effector Mechanism/Movement Organization

Once the performance environment has been perceptually analyzed and a plan of action has been selected, the effector mechanism organizes the movement response and sends the appropriate series of commands to the muscles. That is, the central effector mechanism organizes and initiates the broad plan of action which the performer selected as appropriate to both the goal of performance and the specific environmental conditions (e.g., crosscourt forehand stroke in tennis). Within the general plan for response, specific components of the movement (e.g., stance, grip, backswing, and so forth) must be hierarchically and sequentially organized (Fitts and Posner, 1969). In addition, provision must be made for matching specific parameters of the movement to the characteristics or constraints of

the environment (Bernstein, 1967). The organization of the response must achieve a movement-environment match relative to spatial characteristics (orientation and extent movement), temporal characteristics (pacing and duration of movement), and spatial/temporal characteristics such as velocity, acceleration, and force of movement (Spaeth-Arnold, 1976).

Fitts and Posner (1969) used computer terminology to further describe the process of movement organization. The overall plan of action is called the executive program; units of movement organized to implement the plan are called subroutines. The executive program supplies the overall logic and direction for the movement and orders the sequential execution of selected subroutines. In addition, the executive program is relatively flexible and allows for ongoing decision-making and adaption of movement if errors occur during movement execution. In contrast, the subroutines are not flexible; they are fixed sequences of movement. Subroutines represent well-learned movement sequences which have been relegated to a subcortical level of control in the nervous system. Therefore, subroutines can be repeated again and again unless interrupted by the executive program. Since subroutines can be executed without conscious control, the central processing channel is free to deal with analysis of changes in the environment, general strategy of the response, and alteration of movement characteristics.

In swimming, for example, the general plan for the front crawl stroke constitutes an executive program. The sequences of movement executed by the arms, legs, and head constitute subroutines for the component actions of arm stroke, kick, and breathing in the front crawl (Robb, 1972). Skill in swimming requires that the performer's repertoire of subroutines includes the appropriate component sequences of movement. In addition, the executive program must order and coordinate the execution of the subroutines in the appropriate relation to one another.

In closed skills, the performer attempts to duplicate a pattern of movement that has been successful in a particular situation in the past. For example, a highly skilled golfer is said to have a "grooved swing" which can be duplicated again and again. For each set of environmental conditions encountered during play, the skilled golfer will have available from memory stores a well-organized plan of action that has been used many times before and is exactly matched to the constraints of the environment. For a particular shot such as a drive, the plan includes selected subroutines for the components of grip, stance, swing and follow-through. In addition, the executive program includes specifications for the appropriate sequential order and timing of the execution of the subroutines.

In open skills, the performer must have a large repertoire of plans of actions due to the variety of contexts in which performance occurs. Successful performance would require many motor programs, each comprised of subroutines and specifications for sequencing and timing that are matched to specific sets of environmental conditions. It is likely that in an open skill such as tennis, the performer rarely performs the same response in exactly the same way due to the variability in both the environment and

in the position of the performer's body and limbs prior to the movement response (Bernstein, 1967). But movement organization cannot be explained by the formulation of an infinite number of programs of movement. This is unreasonable. Moreover, it is difficult to explain the ability of an open skill performer to organize a new response to a novel situation in terms of one-trial learning of a new motor program. Therefore, movement organization is described in terms of a motor schema (Pew, 1974), rather than a motor program, particularly for the performance of open skills.

A motor schema is a flexible plan of action which represents general characteristics of a movement sequence, such as the spatial pattern, that are applicable to a number of specific movement responses in relation to a particular goal. A schema is analogous to a formula for movement in which the parameters (e.g., spatial, temporal, and force characteristics) are represented by variables (e.g., x, y, and z). The exact nature of a particular movement(the specific parameter values) is determined or organized relative to the specific demands of the environment and the specific goal of the performer at a given point in time. For example, if a tennis player has a schema for a forehand stroke, the exact characteristics of space, time velocity, and force for an actual stroke will vary for each specific use of the forehand. Since neither the player nor the ball will be in exactly the same position, under exactly the same conditions for each forehand stroke, the stroke must be modified to meet the exact requirements of each specific situation. What is developed during learning of an open skill is a motor schema that contains all of the parameters necessary to generate a unique movement to meet the specifications of each performance situation. It seems that what is stored during learning of an open skill is not a series of specific motor programs, but rather a more abstract formula of movement from which specific patterns of movements are generated to suit the specific needs of a particular performance situation (Schmidt, 1975).

Selective Filtering

Successful selection and organization of a movement response clearly depends upon a complete and accurate assessment of environmental demands. However, since the mechanisms of the central channel have a limited capacity for information, the performer cannot and does not process all the stimuli in the immediate performance environment. One of the most critical elements in successful performance of motor skills is the ability to attend to only the relevant stimuli in the environment and to ignore irrelevant stimuli. For example, the baseball batter is confronted with many environmental stimuli from a variety of sources including signals from the coach, actions of fielders and baserunners, movement of the pitcher and ball, and "chatter" from the catcher, teammates, and spectators. Clearly, stimuli associated with the pitcher and the ball are most relevant to successful performance and should constitute the focus of the batter's attention. The batter must learn to ignore comments from the catcher which are intended to divert the batter's attention and are irrelevant to

performance. The importance of information from the coach, teammates, and opposing players depends upon the particular situation. The process of actively focusing attention on certain aspects of the environment while ignoring others is called selective attention. The mechanism which performs the selective function on input is called a selective filter. The filtering mechanism does not guarantee that the most appropriate information will be processed; it only provides for an active selection of input data by the performer.

Broadbent (1958) proposed the existence of a selective filter, or series of filters, between the receptor level (input) and the central level (perceptual mechanism) within the information processing system (see Figure 3.3). Once the goal performance is identified, the performer actively selects data from sensory input to which attention will be directed. The selection of data for processing is influenced by characteristics of the current sensory input such as novelty and intensity of stimuli, and by past experience, instructions, expectancies, and personal priorities (Norman, 1967; Sage, 1977). Experience within the performance environment enables the performer to identify which aspects of the environment convey little relevant information and which contain information essential to response planning. One of the most important functions of the teacher is to identify the environmental cues which are most relevant to successful performance and direct the learner's attention to them.

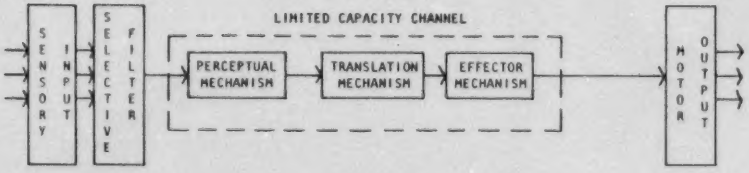

Figure 3.3. Information-Processing Model: Broadbent's Selective Filter

The interaction of past experience, current stimuli, and expectations in determining the focus of a performer's attention was illustrated in a well-publicized incident during the second game of the 1978 World Series of Baseball (Fimrite, 1978). The Dodgers were leading the Yankees 4-3 in the last half of the ninth inning. The Yankees had two outs with runners on first and second base, and Reggie Jackson was at bat. With the count 3 balls and 2 strikes, Jackson swung and missed what appeared to be an "ideal" pitch, thereby striking out instead of driving in the winning runs for the New York Yankees. Jackson later commented that he should have hit

the ball since he had followed its initial flight and was prepared to swing. However, his attention was momentarily diverted from the pitch by the sudden movement of the baserunners toward second and third base, directly across his line of vision. With a full count and two outs the baserunners, of course, were moving with the pitch. However, Jackson stated that he was so intent on the pitcher that he "lost track of the situation." As a result, he was not expecting the runners to break for second and third base. Jackson's attention was diverted from the characteristics of the ball to the rapid, unexpected stimulus in the background of the visual field, as a result, the movement response was unsuccessful.

One characteristic which differentiates a skilled performer from a novice is the ability to quickly identify relevant environmental information and focus attention appropriately. In addition, the skilled performer seems to be capable of processing a greater proportion of the available information in the environment than is the case for a beginner. Therefore, the development of skill in selective attention is an important consideration for the teacher and/or coach.

Orienting

The reception of information from the environment is facilitated by orienting movements. Orienting movements are instrumental responses used to focus or adjust the sensory structures to effectively receive environmental input. Gentile (1972) identified three types of orienting movements: previewing, tracking, and simple orienting movements. For motor skills involving maintenance of body stability within a stable environment (e.g., golf), simple orienting movements are adequate for the reception of sensory information. Since neither the performer nor the environment is moving, environmental information may be obtained by simply looking, listening, and touching.

When the performer is moving, within either a stable or moving environment, more complex orienting is required. The performer must predict where he or she will be in relation to environmental features at a future point in time; the performer must "look ahead." The orienting movement required whenever performance involves body transport is called previewing. The critical factor in previewing is the rate of the performer's movement. For a particular rate of body transport, the performer must look for a given distance ahead to obtain information about objects in the environment in time to subsequently avoid or contact them. The problem confronting the performer is much the same as that facing the driver of an automobile at night. In order to avoid hitting an object or person, the driver must be able to stop the vehicle within the fixed distance illuminated by the headlights. If the stopping distance for a given rate of speed exceeds the "previewing" distance, the rate of speed of the automobile must be decreased. The sports performer must adjust either the rate of body transport or the previewing distance in order to take effective action in relation to objects in the environment. The need for previewing in a variety of

situations is illustrated in the classic maternal admonishment, "If you would look where you are going, you would't run into people all the time!"

For motor skills performed within a moving environment, the performer must predict where the moving objects or people will be at a future point in time, in order to plan a successful response. The orienting movement required in the performance of open skills is called tracking (Gentile, 1972). Tracking is involved in a variety of sport skills e.g., catching a football and passing a baton in a 4 X 100 relay. In both examples, the performer must maintain visual contact with a moving object in order to obtain relevant information regarding the speed and direction of the object's movement. Tracking is required whenever elements of the environment are moving, regardless of whether the performer is stable or moving. When performance takes place in a moving environment and the performer is also moving, both tracking and previewing are essential to obtaining critical environmental information.

Consider the orienting movements and subsequent predictions made by a baseball outfielder attempting to catch a long fly ball. A preliminary prediction of the general flight path of the ball is made on the basis of brief tracking of the initial ball flight; the outfielder turns away from the ball and runs toward the anticipated area of interception. While running, the outfielder must preview the environment to avoid colliding with the fence. Turning the head back to track the approaching ball provides information for an updated evaluation of flight characteristics and a refinement of the body transport plan. As the outfielder nears the predicted interception point, he must track the movement of teammates to avoid collision, as well as track the terminal ball flight to insure interception. As the performer nears the fence, the need for visual previewing is eliminated; information regarding the environment is supplied by contact with the "warning track." Thus, the outfielder adjusts the movement response on the basis of sensory information obtained from both previewing and tracking. A summary of the orienting movements required by each category of tasks within Gentile's taxonomy is presented in Figure 3.4.

Feedback

Feedback is information regarding the output of the system; it serves to identify the effect of the response that occured and/or how it was executed. Feedback information becomes new input to the system, permitting an evaluation of the component processes in terms of the resultant output characteristics. Feedback may be of two general types: (a) knowledge of performance (KP); that is, information about the spatial and temporal characteristics of the response, and (b) knowledge of results (KR); information about the outcome of the response. The performer compares the goal of performance (e.g., hit the target) with information about the result of the response (e.g., where the projectile hit), to determine the effectiveness of the response in goal-attainment. The plan of movement is compared with feedback regarding the characteristics of the actual response (KP) to determine the degree to which the movement was executed as

NATURE OF ENVIRONMENT	NATURE OF MOVEMENT: BODY STABILITY — NO LT/M	BODY STABILITY — LT/M	BODY TRANSPORT — NO LT/M	BODY TRANSPORT — LT/M
S	SIMPLE ORIENTING MOVEMENTS	SIMPLE ORIENTING MOVEMENTS	PREVIEWING	PREVIEWING
S/T	TRACKING	TRACKING	PREVIEWING TRACKING	PREVIEWING TRACKING

Figure 3.4. Gentile's Taxonomy of Orienting Movements

planned (Gentile, 1972). Based on these two comparisons, the learner decides what to do on the subsequent performance trial, either repeat the same response or alter it. Thus, in processing feedback information, the central mechanism provide answers to the questions, "What did I do?" (stimulus analysis); "How did it work" and "What to do next?" (decision-making); and "How to do it?" (movement organization). Feedback information is also used to evaluate the selection of input for sensory analysis and to adjust the focus of selective attention, if necessary. Thus, feedback serves an evaluative, error-correcting function within the information-processing system, and the effective use of feedback is crucial to achieving a response that is matched to environmental demands.

Memory

Memory mechanisms are also essential to the effective processing of information. Long-term memory is a relatively permanent store of past experiences, influencing both the selection of data from sensory input and the decision of how to respond in a given situation (e.g., the learner may decide not to respond, to respond differently, and so forth). Long term

memory also serves as a storehouse for motor plans and component subroutines comprising the learner's "movement repertoire." Short term memory allows data to be held in temporary storage, prior to analysis and processing of the information in the central component of the system (Keele, 1973). The duration of this temporary storage may be increased through rehearsal of the input data. A complete discussion of memory mechanisms and functions is beyond the scope of this presentation and the reader is referred to Marteniuk (1976) for additional information on the topic.

Motor output may also be held in temporary storage, once the initial movement organization has been completed. A choice delay mechanism provides for a delay in response until the optimal execution time occurs and/or until further relevant data are analyzed (Conrad, 1955). The memory and delay mechanisms serve to expand and refine the adaptive nature of the information-processing system. A composite information-processing model is presented in Figure 3.5.

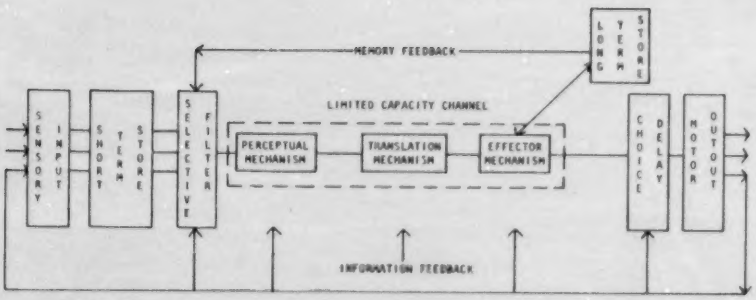

Figure 3.5. Composite Information-Processing Model

The list of component processes in the performance of motor skills is impressive not simply in terms of numbers, but also in terms of the

diversification and sophistication of the subsystems. In addition, a hierarchy of processes exist within each component of the system; only the general process for each component has been identified in this presentation. For example, the perceptual analysis of environmental input is not unitary process. Rather, stimulus analysis often requires identification, discrimination, prediction, and consolidation processes if the resultant perception is to be both accurate and meaningful. The dynamic interaction and integration of the component processes within the overall framework of performance is a striking demonstration of the complexity and adaptability of the perceptual-motor system.

Information-Processing and Performance

Once the goal of performance is identified, the performer actively selects data from sensory input to which attention will be directed. Sensory input includes information from the external environment, from the internal environment, from memory stores, and from feedback mechanisms. The selection of data for processing is influenced not only by the goal of the activity, but also by the characteristics of the current sensory input and by past experience in related situations. Input data may be held temporarily in short term storage, prior to analysis by the central processing mechanisms.

Within the central processing channel, stimuli are analyzed to provide an evaluation of the current environmental situation. A decision is made relative to the nature of the response and a broad plan of action, or executive program, is formulated. Subsequently, a central effector mechanism organizes the movement response. In terms of individual morphology and within the biomechanical constraints of the activity, the performer draws upon past movement experience to organize a movement sequence that will allow for goal-attainment within the particular performance context. A choice delay mechanism provides for temporary holding of the movement response until the optimal time for execution occurs.

After executing the response, the performer monitors relevant feedback, reenters the information-processing cycle, and makes a decision relative to the nature of the next response. Based on feedback about both the characteristics of the movement and the outcome of the response, a decision is made to either alter the response or to repeat it as exactly as possible. The performer must analyze what was done and how effective it was. It may be necessary for the performer to alter the sequencing of subroutines, correct faculty subroutines, create new subroutines, or smooth the temporal patterning of the response. In addition, a decision may be made to alter the focus of selective attention, incorporate alternative past experiences, or cease responding completely. Finally, the performer stores the motor program and an evaluation of response effectiveness in long-term memory, where the information remains potentially accessible for future processing requirements.

Information-Processing and Learning

The effectiveness of both the information-processing and the resultant movement response are a function of the stage of learning during which performance occurs. The more complex the task and/or the more inexperienced the learner, the greater the information-processing load and attention demands. Task complexity is related to the amount and variability of environmental input, the number of response options, the length of the movement sequence, and the number of movement components. The beginner is confronted with a large quantity of information and, as a result, takes a long time to formulate and execute a response. In open skills, it is not unusual for the beginner to evidence a response which is appropriate to the spatial demands of the environment, but which is executed too late to be effective (e.g., hitting the ball late in tennis, swinging "behind the ball" in baseball, and so forth). If the beginner reacts more quickly in an attempt to match the temporal characteristics of the environment, it is likely that all of the relevant information will not have been sufficiently processed and therefore, the response will be incorrect. Typically, a beginner either takes a long time to respond correctly, or responds quickly but inappropriately in terms of the particular performance conditions.

In order to execute a skill well, that is effectively and efficiently, the performer must reduce the information load to manageable dimensions. However, consider the difficulty of the task for the beginner.

The beginner is unsure as to the appropriate focus of attention. Discriminating between relevant and irrelevant environmental cues requires experience in the particular performance situation.

The beginner requires a long time for the perceptual analysis of input. The beginner must often track a ball for most of its flight path, since use of information from the initial flight path to predict the future position of the ball requires familiarity with flight characteristics gained from experience in the situation.

The beginner is unsure of the appropriate decision relative to a plan of action. The beginner may not even be aware of the response for a given situation.

The beginner has no firm schema for movement organization. The development of a schema of movement may be a major task of itself, particularly if the learner has a limited background of movement experiences to apply to the new situation.

The beginner may have difficulty with the performance of simultanous movements. If attention is focused on one aspect of performance, e.g., swinging the racket in the tennis serve, than success in performing the second movement task, e.g., the ball toss, will be, at best, a matter of chance.

The beginner performer is faced with maximum attention demands on the central processing system and with insufficient experience in this situation to accurately reduce the information load. An analogy can be drawn between the beginning performer and an individual seeking employment for the first time. The novice worker cannot obtain employment because all employers require previous job experience, but, vocational experience cannot be gained because the worker cannot obtain a job!

Clearly, performance of sport skills is literally more difficult for the beginner than for the advanced player. A skilled performer appears to have more than enough time to monitor the environment, plan a response, and execute an effective sequence of movement. Movements of an advanced player are typically executed smoothly and in synchrony with the temporal demands of the environment. The skilled performer has effectively reduced the information load on the processing system.

Stimulus Analysis

Since individuals have a limited capacity for attending to simultaneously-presented stimuli, the sport performer must attend to only selected aspects of the environment. In team games, many events compete for the beginner's attention including the actions of teammates and opponents, the need to plan and execute a movement sequence as part of a team play, and the feedback of information regarding previous responses. A beginner cannot be attentive to all sources of information and frequently makes mistakes in performance because the perceptual analysis of the situation was based on information from a limited number of sources (Marteniuk, 1976).

A highly skilled performer is able to reduce the amount of information that must be processed from any one source and, therefore, is able to attend to almost all relevant aspects of the environment. Relative to stimulus analysis, the skilled performer can predict with considerable accuracy which events are most likely to occur. In addition, the performer is able to use contextual cues to either verify or modify the prediction. For example, a skilled tennis player is able to predict, through experience, the placement of the opponent's return based on analysis of the game situation, position of the opponent and placement of the hit to the opponent. By watching the opponent's movement to the ball and initial movements in hitting, the experienced player can verify and update the prediction of where the ball will land. Thus, the outcome of the situation may be "known" to the skilled performer by the time the ball leaves the opponent's racket. Therefore, it becomes unnecessary for the player to monitor the complete flight path of the ball, since it supplies redundant information. Attention can be focused on moving to meet the ball and selecting and organizing the subsequent return. Only a few brief samples of information about flight characteristics of the ball are needed to verify the final outcome of the opponent's response. Essentially, the skilled performer is able to ignore considerable amount of input information because of the ability to accurately predict the outcome of events based on expectations and contextual cues.

Because of lack of experience in the particular performance situations, the beginning player can neither predict the outcome of the opponent's response nor evaluate the situation from early contextual cues. Thus, the beginner must process much more information to reach the same perception of a situation as a skilled player. It is important for the teacher to help the learner identify similarities and differences in performance contexts, interpret movement cues of the opponent, and predict the outcome of events such as ball flight as soon as possible. In this way, the learner is gradually able to reduce the frequency of environmental monitoring, reduce the amount of information that must be processed from any one source and, thereby, gain the ability to monitor all relevant sources of information.

Decision Making

The decision mechanism must select from memory an appropriate plan of action that will meet the demands of a particular situation. Effective decision-making requires accurate identification of the specific characteristics of the environment by the perceptual mechanism. In addition, the performer must have available in memory a relatively large number of previously-learned plans of action related to the particular activity. A skilled performer is able to quickly perceive the relationship between specific environmental demands and the specific plan of action that will best meet those demands. The greater the performer's experience in a particular sport skill, the more apparent the "stimulus-response" pairings become. Since the beginner may not immediately perceive the relationship between a given movement plan and a specific performance situation, considerable time may be required to select a plan of action.

Even if the performer can quickly identify the appropriate response for a particular situation, retrieval of the plan of action from memory requires time and attention (Keele, 1973). If the performer has no idea what plan of action might be required until the complete situation unfolds, the time required to select an appropriate plan could be longer than the total time available for information-processing. The skilled performer can reduce the time required for decision-making by selecting in advance those plans of action most likely to be used, thus reducing the number of alternative plans from which selection must be made. That is, the skilled performer uses probability characteristics of the performance environment to prime certain plans in the response repertoire as more likely to be used in given situation than others (Gentile, 1972; Sage, 1977). First, the performer must determine the likelihood of occurance of a given environmental event (e.g., a lob by the opponent in tennis). If the probability is low, the corresponding movement response (e.g., overhead smash) is not primed; if the probability is high, the corresponding plan of movement is readied for selection and use.

For many open skills, the prediction of environmental events and subsequent priming of response can be facilitated by the use of conditional probabilities associated with environmental events. In sport skills such as tennis, badminton, and fencing the likelihood that a given environmental

event will occur is dependent, in part, on the nature of the performer's current response. For example, based on the characteristics of his own response, the skilled tennis player can predict the most likely returns of the opponent. Since the opponent's return constitutes the stimulus to which the performer's next response must conform, the skilled performer can begin priming response possibilities on the basis of conditional probabilities associated with the current response. That is, having "set-up" the opponent, the performer can immediately begin planning the next response.

The ability to predict environmental events not only reduces the information load on the perceptual mechanism, but also enables the performer to reduce the number of plans of action to be evaluated by the decision mechanism. Many alternative courses of action can be eliminated as highly improbable and the remaining plans can be ordered in terms of their probability of use. As a result, the skilled performer is ready for the most probable event, and decision-making is relatively simple and quick. In contrast, the beginner has no basis for determining which events are most probable in given game situations. Because of this uncertainty, both perceptual analysis and decision-making require considerable time for a novice performer. As a result, the beginner's performance is frequently characterized by slow and/or inaccurate responses.

Movement Organization

A major difference between a beginning and an advanced performer of sport skills is the number of well-organized programs (or schemas) of movement available to the effector mechanism. Skilled performers have in memory storage many well-learned plans of action that can be "run off" with minimal conscious attention once they have been selected for use and ordered into execution. The skilled tennis player, for example, does not have to consciously organize and monitor the execution of each stroke; therefore, the information-processing load on the effector mechanism is reduced. In contrast, the beginner has few well-learned sequences of movement in memory. Therefore, the beginner must devote considerable attention to the organization of individual responses, thus increasing the processing demands during performance.

In formulating an executive program for a new skill, the learner draws upon past experiences in the form of previously-acquired sequences of movement. In learning tennis, for example, a learner who has had a broad background in other racket sports will have a larger repertoire of subroutines that could be used in tennis (e.g., grip, stance, and so forth) than will a learner with a more limited background. The less experienced beginner may possess some of the necessary subroutines to perform the new skill. However, some components of response, which constitute fixed subroutines for a more advanced player, may have to be learned as separate subskills. For example, the proper footwork and body positioning for a forehand drive in tennis can be considered a subroutine for an experienced player. However, for an inexperienced beginner, this same component of performance may constitute an executive program containing several

subroutines. Indeed, for a beginner, the overall executive program for a forehand drive may consist not of subroutines, but of a series of smaller executive programs, each controlling a number of small subroutines of movement. Execution of each of the smaller, component programs of movement would require conscious attention, thus increasing the information-processing load for the beginner.

As learning progresses, the performer gains the ability to organize and execute larger units of movement. Individual subroutines become linked to form larger subroutines of movement. Executive programs for components of the skill become well-learned sequences (i.e., one large unit of movement), and can be incorporated as subroutines under the larger executive program for the skill. For example, the movement organization for a beginning tennis player may consist of individual execution programs and related subroutines for each component of performance such as stance, backswing, forward swing, and follow-through. With practice, the individual subroutines are grouped into larger and larger units until performance of the forehand drive is regulated by single executive program, controlling the sequential execution of several (e.g., four) larger subroutines of movement. The ability to relegate larger units of movement to a lower, semi-automatic level of control in the nervous system, reduces the information load on the central processing system and frees the performer to attend to strategy and necessary response modifications.

Feedback

Feedback, information about the characteristics of the movement and the outcome of the response, is used by the performer to evaluate the effectiveness of the component processes of performance. Based on both knowledge of performance and knowledge of results, the performer must decide whether to alter the response or repeat it as exactly as possible. In order to make this decision, the performer must answer two questions: (a) Did I move as I planned? and (b) Did I accomplish the goal? (Gentile, 1972). The concept of assessing the degree to which the movement was executed as planned is an essential element in the problem-solving, information-processing view of learning. Until the beginner executes a movement sequence as planned, no judgement can made as to the effectiveness of the selected response.

If the novice learner decides that the movement was executed as planned and the goal of performance was accomplished, it is likely that the plan of action will be repeated when the same performance situation occurs again. If, however, the movement was successfully executed in the view of the learner, but the goal was not attained, it is likely that the movement plan is faulty. Perhaps the learner failed to correctly analyze the environmental constraints and, therefore, organized an inappropriate sequence of movement. The learner may be able to correct the organization of movement on the subsequent response, particularly with help from the teacher.

The process of response evaluation may result in two additional outcomes (Gentile, 1972). The learner may decide that the movement was

not executed as planned, although the goal of performance was accomplished. On the subsequent performance trial, the learner may attempt to repeat the "incorrect" pattern of movement since it did result in goal-attainment. Indeed, under the definition of skill presented in chapter two, this strategy would seem appropriate for many motor tasks. However, since the response was originally unplanned, it may be difficult for the learner to reproduce it. An alternative strategy is to attempt to successfully execute the original plan of action in order to evaluate its effectiveness. This procedure would tend to permit a more systematic analysis of performance. The final possibility in response evaluation involves failing to execute the movement as planned and also failing to attain the goal. Clearly the learner must attempt the task again. However, if the learner repeatedly fails at both aspects of performance, guidance from the teacher is necessary for progress to occur.

As learning progresses, the performer becomes more consistent in successfully executing selected plans of movement. Motor plans that are judged effective in achieving the goal of performance are placed in long-term memory for future use in specific situations. With practice, there is also a shift from the use of visual information concerning the outcome of performance to the use of proprioceptive information to evaluate the outcome of a response (Fleishman and Rich, 1963). For example, a skilled tennis player may not have time to wait for visual feedback about the results of a stroke. Instead, the highly skilled player can evaluate the flight path of the stroked ball on the basis of proprioceptive information; that is, the "feel" of the movement. By predicting the outcome of the response on the basis of proprioceptive feedback, the skilled performer can reduce the time required for response evaluation and subsequent decision-making.

The ability of the skilled performer to recognize and classify proprioceptive feedback from various movements is the result of consistently executing many similar movements in the past. In contrast, the beginner cannot use movement-produced (proprioceptive) feedback in evaluating response effectiveness. The beginner has had few opportunities to experience proprioceptive feedback from "correct" responses, since performance is erratic and relatively large response errors are still frequent. As the learner becomes more consistent in executing selected plans of actions, the proprioceptive feedback from various patterns of movement becomes dependably differentiated and plays an increasing role in the evaluation and control of movement. As was the case for the other components of the system, the change in the nature of response evaluation results in a reduction in the time required to carry out the particular process, thus contributing to the efficiency and effectiveness of information-processing.

Factors Influencing Information-Processing Ability

Many factors may limit performer's ability to process information efficiently and effectively. In this section, examples of factors related to the environment, the learner, and the task are presented. The influence of

uncertainty regarding the performance environment on the efficiency of information-processing are described. The effect of the learner's age and activation level on the effective processing of information are discussed briefly. The requirement for simultaneous performance of stability/transport and limb/object manipulation are examined in greater detail.

Environmental Uncertainty

The efficiency of information-processing depends, in part, on the amount of information. The concept of information load does not simply refer to the number of individual stimuli in the performance environment. The information load is directly related to the amount of uncertainty presented to the performer by the environment. The major source of uncertainty is the number of possible environmental events and alternative plans of action confronting the performer, as well as their predictability (Marteniuk, 1976). The greater the number of possible events or the greater their unpredictability, the larger the amount of information confronting the performer. As the number of events becomes fewer or as the events become more predictable, the uncertainty for the performer (the amount of information to be processed) becomes less. The time required for decision-making is directly related to the information load (uncertainty) presented by the performance environment.

Three sources of uncertainty in the performance environment which seem to have the greatest relevance of the performance of sport skills are temporal uncertainty, event uncertainty, and difficulty of discrimination (Marteniuk, 1976; Sage, 1977). Temporal uncertainty is present when a performer knows what environmental event will occur but is uncertain exactly when it will occur. For example, members of the defensive team in football know that the ball is snapped from center to quarterback, but they do not know exactly when it will occur. A skilled quarterback varies the count and the cadence of signals for snapping the ball to prevent the defense from anticipating, and thus cause a slight but potentially significant delay in their reactions. In many sport skills, performers vary the pace of the game or the speed of the ball in order to increase the temporal uncertainty for the opponent. Failure to do so allows the opponent to predict the occurrence of environmental events and thus reduce response delay.

Event uncertainty is present when the performer does not know which of several likely events will occur in the performance environment. Event uncertainty, like temporal uncertainty, results in a response delay since selection of an appropriate response cannot be made with confidence until one of several events occurs. In most game situations, a number of alternative events could occur. For example, on the first-down in football, the offensive team could execute any one of several running or passing plays. In tennis, the return of a deep baseline shot may travel cross-court or down the line, may possess top spin or back spin, and may land short or deep in the court. As the number of possible events increases, the uncertainty and subsequent delay in response also increases. Thus, the larger the

performer's repertoire of potential responses, the greater the event uncertainty for the opponent. However, if some events can be labeled as more probable than others, or if it is known that certain events generally follow from prior events, the performer can reduce the amount of event uncertainty in the situation. Knowledgeable football players use information concerning the game score, field position, time remaining, and strengths and preferences of the opposition to predict which of several events will occur on an ensuing play.

The third factor influencing response delay is the degree of difficulty involved in discriminating among the possible environmental events. The greater the resemblance among environmental events, the greater the time required to discriminate among them. In this case the response delay is attributable to uncertainty, and subsequent delay, to perceptual processes upon which subsequent response selection is based. For example, the option play in football is designed to increase the difficulty for the opponents in discriminating which of several events is occurring (e.g., hand-off, roll-out pass, quarterback keeper, and so forth). Each of the options begins the same way, and the particular offensive maneuver becomes apparent only after the play is well underway. A well-executed option play forces the opposition to delay decision-making, hopefully until it is too late to successfully stop the play. A similar strategy is used by skilled performers in racket sports. By executing the preparatory movements for an overhead clear, drop shot, and smash in an identical fashion, the skilled badminton player presents the opponent not only with event uncertainty, but also with uncertainty due to perceptual discrimination. The closer the resemblance among different movements, the greater the time required for perceptual discrimination. The skilled performer is able to accurately "read" subtle cues from the opponent's movement and thus initiate appropriate action with minimum delay.

In addition to the delays in decision-making due to uncertainty regarding environmental events, the performer's ability to process information is also limited by a characteristic of the decision mechanism itself. Only one decision can be made at a time; a second decision cannot be made until the first decision-making process has been completed (Marteniuk, 1976). If two relevant environmental events occur in rapid succession, the time required for the performer to react to the second event is longer than if the event had occurred either alone or first in the sequence. The delay in reaction to the second stimulus event is due to the time required to complete the processing of information associated with the first event.

The technique of "faking" an opponent in sport skills is designed to capitalize on this characteristic of the decision mechanism. For example, in basketball, the offensive player often fakes a movement in one direction and then quickly executes the intended movement in the opposite direction. If the defensive player "takes" the fake and begins searching memory for a plan of action appropriate to the fake, a second decision related to the actual movement of the opponent cannot be made until the first decision process is completed. That is, even if the perceptual mechanism recognizes

the second movement of the offensive player as the "real" movement, the defender may not be able to act on that information quickly enough to stop the offensive player, due to the unavoidable delay in decision-making. Thus, a fake may be effective even if the opposing player does not initiate movement in response to the fake. If the perceptual mechanism does not recognize the movement as a fake and the decision mechanism subsequently initiates a search for a plan of action, the performer cannot correct the processing error until the initial decision-making is completed. Frequently, this delay is sufficient for the offensive player to "lose" the defender.

Clearly, the length of the time interval between the fake and the intended movement is crucial to the success of the fake. If the two events occur too close together in time, the opponent may not have initiated decision-making in relation to the "fake" prior to the actual movement and, therefore, little or no delay would occurr in reaction to the second event. In contrast, if the two movements are too widely separated in time, decision-making relative to the "fake" will have been completed in time for the performer to react without delay to the intended movement.

Age

A number of limitations in the information processing ability of children have been reviewed by Rothstein (1977). For example, there is a direct relationship between age and speed of processing for visual information; visual processing is slower for children than for adults. In addition, younger children tend to perceive fewer relevant environmental stimuli than older children. Older children seem better able to focus attention on relevant stimuli and to shift attention to new sources of relevant information. Due to lack of experience, children often have a poorly defined perceptual framework within which environmental stimuli are interpreted. Therefore, children tend to be inaccurate and/or slow in perceptual analysis, thereby impairing the subsequent processes of response selection and organization and increasing the total time for information-processing. Reaction time is slower for children than for adults. Therefore, to be successful, a child must actually initiate the response for many open skills sooner than an adult. The longer reaction time delay also limits the child's ability to organize and initiate an error-correcting response based on feedback from an ongoing sequence of movement. Thus, the general limitation on information-processing ability in children is a time factor. The limited past experience and systematic lags in processing combine to produce delays and/or inaccuracies in the information-processing ability of children. The reader is referred to Rothstein (1977) for a more complete discussion of this topic.

Activation Level

A second characteristic of the learner which limits the efficiency and effectiveness of information processing is the activation level of the

performer. Activation refers to the readiness of the central nervous system to receive and process information efficiently (Marteniuk, 1976). The relationship between activation level and performance generally takes the form of an inverted U; that is, the level of performance increases as the level of activation increases up to an optimal point, beyond which further increases in arousal result in performance decrements (Duffy, 1962; Birch & Veroff, 1966). It has been hypothesized that for every motor skill there is an optimal level of activation, usually moderate, that results in maximum performance. However, the degree of nervous system activation that is optimal for a given activity depends upon the type of task being performed and the skill level of the performer.

Level of activation or arousal influences the efficiency of perceptual, cognitive, and motor functioning. Therefore, the amount of activation that will facilitate or interfere with performance of a particular motor skill depends upon the extent to which the skill requires each of the above processes. Oxendine (1970) suggested that a high level of activation facilitates performance of motor skills which require strength, endurance, and speed (e.g., football blocking and tackling, weight-lifting, and sit-ups). Conversely, high activation may interfere with performance of skills requiring fine muscle coordination, steadiness, and decision-making (e.g., archery, golf putting, basketball free throw, and "school figures" in ice skating). Some sport skills, such as soccer, require not only speed and endurance which are facilitated by high levels of activation, but also require analysis of opponents' movements and decisions regarding strategy which may be impaired if the level of activation is too high. Thus, the task of determining optimal activation level is not a simple one. Further, the optimal level of activation for performance of well-learned skills may differ considerably from the best activation level for maximum performance during learning. In addition, the wide range of inter-and intra-individual differences further complicates the determination.

The optimal level of activation for maximum performance of motor skills depends in part, on the amount of cortical activity inherent in performance of a particular skill. Since the initial stages of learning seem to involve extensive cognitive activity (e.g., evaluation of the situation, selection and planning of response, and the like), high levels of activation may be inherent in the performance of most motor tasks by beginners. Therefore, if students are intrinsically motivated to learn a particular skill, the teacher's use of motivational techniques designed to increase activation level during the initial stage of learning would seem to be ill-advised. It is likely that cortical activity decreases after the initial stage is completed, and teacher-induced activation may facilitate performance during later practice of a motor skill. However, decisions regarding the use of motivational techniques to increase activation must be based on a consideration of both the stage of learning and the nature of the task. For example, the learning of complex skills may inherently involve such a high level of activation that the teacher should attempt to reduce activation in order for maximum performance to occur. On the other hand, learning of simple skills and

performance of well-learned skills, whether simple or complex, may benefit from increased activation. Additional factors influencing level of activation and subsequent efficiency of information-processing include the characteristic arousal level of the individual and the nature of the performance situation (e.g., "friendly match" vs. tournament play). Thus, the task for the teacher or coach is to estimate the best level of activation for a specific skill at a particular stage of learning, consider the individual's characteristic level of arousal, and apply motivational techniques designed to increase or decrease the level of activation, as appropriate, if optimal performance is to occur.

Simultaneous Performance of Two or More Tasks

A major factor influencing the performer's ability to process information is the requirement to perform two tasks simultaneously. The potential limitation imposed by simultaneous performance of two tasks is related to the performer's limited capacity to process information. If the processes required to perform one task (e.g., skip) require a majority of the performer's information-processing capacity, the remaining processing capacity may be insufficient for successful performance of the second task (e.g., dribbling a ball) (Marteniuk, 1976). The critical factor is the amount of attention required by the information-processing tasks associated with each of the skills to be performed. If the combined processing requirements of the two skills are within the total processing capacity of the individual, maximum performance of both skills should occur. However, if the combined demands on attention exceed the central processing capacity, a performance decrement will occur for one or both tasks. That is, if the requirement for simultaneous performance of two skills overloads the processing system, some aspects of performance may literally not receive attention. For example, the tennis player may be able to organize and execute an appropriate swing, or analyze and predict ball flight accurately, but not both simultaneously. Unless one of the tasks is learned well enough to be performed with minimal conscious attention to perceptual analysis, decision-making, and motor control, a performance decrement results in the other.

Tasks can be performed simultaneously if one of them does not require much attention. For example, walking requires very little attention once it is learned, and, therefore, other tasks such as talking, thinking or folding a newspaper can be performed simultaneously. As the learning of sport skills proceeds to advanced levels, components of performance require less and less conscious attention. Thus, a highly-skilled performer can successfully execute the simultaneous body transport/object manipulation responses required by a sport such as field hockey. In addition, the skilled player can attend to additional aspects of performance including analysis of the performance situation and strategy.

One index of children's skill in perceptual-motor activities is the ability to perform two tasks simultaneously. By age six, most children can catch, throw, climb, run, jump, and perform a number of other motor skills quite effectively. However, performance decrements frequently occur when more

than one type of movement must occur simultaneously (e.g., run and dribble a ball). The results of a recent study (Arnold, Note 1) illustrate the effects of age and information-processing load on the performance of perceptual-motor tasks by children. Six and eight-year-old males and females were tested on a two-dimensional battery of perceptual-motor tasks performed in a stationary environment. The stability/transport dimension of the test battery included a task requiring maintenance of balance, a task involving counter-clockwise baserunning (triangle run), and a task requiring several forms of running and several changes of movement direction (patterned run). Each task was performed with no requirement for secondary limb manipulation to obtain baseline scores for the performance of the stability/transport tasks. The limb manipulation dimension of the battery included tasks requiring limb manipulation without an object (hand clapping) and manipulation with an object (string winding). Each manipulative task was performed in a standing position to obtain baseline scores for the limb manipulation dimension of the battery.

To complete the battery, each of the stability/transport tasks was performed in combination with each of the limb manipulation tasks. Scores for the combined tasks provided an index of the child's ability to perform two tasks simultaneously. In addition, comparisons could be made to baseline scores for each dimension of performance in an attempt to identify the nature of performance changes or "trade-offs" as task complexity and information-processing load were increased.

As expected, baseline performance scores for eight-year-old children were superior to those for six-year-old for all five individual tasks. No significant sex differences were observed for running ability. However, at age six, females were superior to males in fine manipulation of an object and in balancing ability.

The overall effect of requiring simultaneous performance of stability/transport and manipulation tasks was a decrement in baseline scores for one or both dimensions of the combined tasks. The extent of the performance decrement depended upon the age and sex of the performer, and on the complexity of the component tasks. In general, subjects maintained their baseline running rate when hand clapping was added to both of the running tasks. However, the clapping rate decreased 22% over all age-sex groups. The decrease in clapping rate was less for males (19.5%) than for females (24.5%).

In contrast, when required to wind string while running, the subjects decreased both the running rate and the string winding rate. Decrements in running rate were 22% for the triangle run and 23% for the patterned run, summed over age-sex groups. The decrements in running rate were greater for six-year-olds than for eight-year-olds, and were twice as large for six-year-old males as for six-year-old females. The decrease in string winding rate when combined with the more complex patterned run was twice as large (31%) as when combined with the triangle run (15.5%).

Baseline balancing scores were only moderately affected by the addition of manipulation requirements for all subject groups except six-year-old

males. Time-in-balance decreased 23% with the addition of a manipulation task for six-year-old males; the decrement was 11.5% for six-year-old females and for eight-year-olds. For the combined balance and manipulation tasks, hand clapping rate decreased 8% across all age-sex groups. In contrast, string winding rate while balancing evidenced a 7% increase from baseline scores for six-year-olds and a 3% decrease for eight-year-old females.

In summary, specific age and sex differences were observed in baseline performance of both body stability/transport and manipulative tasks. Similarly, decrements in performance scores for combined tasks also appeared to be both age and sex related. Relative to information-processing load, the more complex the requirements of the stability/transport task, the greater the decrement observed for the simultaneous manipulation tasks. That is, decrements in manipulation performance were least when manipulation was combined with the balance task and greatest when combined with the patterned run. Similarly, manipulation of an object (string wind) produced significantly larger decrements in stability/transport performance than did the less complex task of limb manipulation without an object (hand clap).

It would seem that in selecting and designing activities for children, the teacher should consider the potential information-processing load placed on the learner, as well as the general characteristics of the tasks discussed in chapter two. The selection of appropriate movement experiences for children does not depend simply on the age and sex of the child, or on the presence or absence of traditional developmental landmarks (e.g., establishment of "fine motor control"). The design of activities depends, in addition, on the background of movement experiences upon which the child can draw in attempting to formulate and execute an appropriate response in a particular situation.

In evaluating activities for children, the teacher should answer the following questions related to the nature of the task, the child, and the processes of performance. What experience has the child had in various forms of body transport? What is the child's background in manipulation skills (e.g., manipulate limbs, manipulate an object, propell an object, acquire an object, balance an object)? What experience has the child had in tasks involving simultaneous performance of stabiliy and manipulation skills or transport and manipulation skills? Is the child familiar with the predictive demands of an open environment? What experience has the child had in decision-making relative to selection from among response alternatives? Is the child's repertoire of basic movements adequate to permit organization of a movement appropriate to the particular situation being presented? Can the child carry out all of the component processing tasks under the time stress inherent in open skill performance? What is the demand on the system relative to the processing of both environmental and movement information? Do the requirements of the task in terms of component information-handling processes exceed the attention capacity of the child? If the activity requires simultaneous performance of two tasks, is the child able to perform one task semi-automatically (with minimal

attention), freeing the information-processing system to monitor the execution of the second task and the coordination of the two tasks?

Available evidence is insufficient to dictate appropriate progressions of developmental skills in terms of the questions raised above. However, by systematically selecting activities, the teacher can obtain information on the ability of the child to perform stability and transport tasks of varying complexity, both individually and in combination with a variety of manipulation tasks. By systematically introducing both closed and open performance environments, the teacher can guide the development of appropriate information-processing abilities such as orienting, predicting, monitoring of relevant sources of feedback, and decision-making. The teacher must gradually introduce complexity in both the nature of the movement and the nature of the environment. For example, rope skipping, an open skill involving body transport, may be presented as an externally-paced skill without manipulation (classmates turn rope), or as a self-paced skill with manipulation (performer turns rope). Similarly, ball-handling skills can be open or closed and can be performed with and without requirements for body transport.

The selection of activities for children must be guided by the expertise, empathy, and intuition of the teacher as well as by information related to task requirements and learning processes. If all relevant factors are systematically evaluated, then the teacher can be confident that activities were not selected randomly, by convenience, or by tradition. Rather, the teacher will have truly designed appropriate movement experiences for a specific group of children.

Summary

Component tasks involved in the performance of motor skills were discussed within the context of an information-processing model. Comparisons were made of the information-processing tasks involved in the performance of open and closed sport skills. Changes occurring in the nature of the information-processing tasks as learning progresses were identified. Differences between beginning and advanced players in the information load for each of the central processes of performance were discussed. The effects of age, environmental uncertainty, activation level, and simultaneous performance requirements on the ability of the performer to process information were identified. Suggestions were made for the design of appropriate movement experiences for young children.

Chapter Four

THE TEACHER: FACILITATING THE DEVELOPMENT OF SKILL

How can the teacher facilitate the process of learning to accomplish a particular type of motor task? What are the major responsibilities of the teacher during learning? How does the teaching emphasis differ for open and closed skills? What changes occur in the role of the teacher as learning progresses? Answers to these questions require consideration of both the learner and the motor task. The nature of the teacher's role at a given point in time is directly dependent upon the nature of the ongoing learning process which, in turn, depends upon the current skill level of the learner and specific task demands. Similarly, the relevance, progression, and success of the learning activities depend, in part, upon the nature of the teaching process. Thus, the three factors interact in a mutually-dependent, dynamic system to determine the process and progress of motor skill learning.

If teaching is defined as the facilitation of learning, then the task for the teacher is to help the learner successfully complete each of the processes involved in the performance of a particular motor task. The responsibilities of the teacher include identifying the goal of the activity and the environmental constraints on performance, structuring the practice situation, directing the learner's attention to critical environmental cues, assisting in movement organization, and providing augmented feedback to assist the learner in evaluating the effect of the selected response. As learning progresses, the teacher must guide the learner toward developing larger units of movement, achieving appropriate timing within and among components of movement, refining anticipatory skills, and effectively using proprioceptive feedback as well as visual information to evaluate the outcome of a response (Gentile, 1972; Stallings, 1973).

To the extent that the specific nature of the processes in involved in performance differ for open and closed skills, the nature of instruction and guidance in executing the component processes must also differ. For a closed skill such as archery, instruction should focus on the development of a consistent pattern of movement matched to the spatial characteristics of the stable performance environment. Emphasis should be placed on the use of kinesthetic/proprioceptive feedback to monitor and refine the sequence of movement. Practice should be structured to assist the learner in progressively narrowing the range of variability in the movement response, thereby gaining consistency in goal-attainment. In contrast, for an open skill such as soccer, instruction should focus on the development of a diversity of movement patterns matched to the variable spatial and temporal characteristics of the changing performance context. Emphasis should be placed on perceptual skills including predictive ability, as well as on rapid and accurate decision-making. Practice should be structured to enable the learner to develop necessary variations in movement responses in order to match an exact environmental demand with an appropriate movement, thereby increasing the frequency of goal-attainment.

A major responsibility of the teacher throughout learning, for both closed and open skills, is the reduction of the information load to a level that is manageable for the particular learner. It has been stressed repeatedly that the human information-processing system has a limited capacity for handling information. If a given task or component of performance places a severe attention demand on one part of the processing system, other operations may be impaired. Reducing the information load frequently involves reducing the complexity of the environmental situation, the complexity of the movement response, or both. However, the teacher must maintain the essential nature of performance under the simplified conditions, if the learner is to develop skill in all of the components of performance. In addition, complexity must be added to the performance situation as soon as the performer is able to deal with it.

This chapter will focus on the teacher's role during the learning of motor skills. The general tasks for learners at different stages of learning will be reviewed. Teacher responsibilities during early and late stages of learning for both closed and open skills will be identified and illustrated. Techniques of reducing the complexity of performance requirements will be suggested, and the mini-game approach to the teaching of sport skills will be elaborated and illustrated. Conclusions will be drawn relative to strategies of teaching which appear most likely to develop skill in sport.

Stages of Learning

The learning of a sport skill is a continuous, incremental process involving progressive gains in both cognitive and motor abilities. At a given point in the learning process, performance may be described in terms of the learner's ability to carry out a series of information-handling tasks. By comparing performance at different points in time, changes occurring in both the nature of the tasks and the learner's ability to process information can be identified. The characteristics of learners at different stages of learning can suggest how the teacher should modify instructions, demonstrations, practice, feedback, and the like, in accord with the skill level of the learner. Clearly, the techniques of instruction for novices will differ considerably from the teaching of highly skilled players.

In an attempt to emphasize the changes occurring in the nature of information-handling tasks during the process of acquiring skill, several authors have identified distinct, although somewhat arbitrary, stages of learning. Gentile (1972) proposed that the learning of motor skills involves two stages. During the first stage of learning, the learner develops a movement pattern that leads to goal-attainment in the initial performance environment. The second stage of learning involves repeated performance of the task with the aim of developing consistent goal-attainment. Fitts (1964) proposed three stages of learning for motor skills: cognitive (planning) stage; associative (practice) stage, and autonomous (skilled) stage. The two authors differ in the terminology used to describe the learning

process, and in the relative emphasis placed on the various information-processing tasks at different stages of learning. Therefore, in this chapter the process of acquiring skill in motor tasks will be discussed in terms of the initial stage of learning and later stage(s) of learning; characteristics of the learner during the two stages of learning will comprise a synthesis of the conceptual suggestions of Gentile (1972) and Fitts (1964).

Initial Stage of Learning

During the initial stage of learning, the learner attempts to understand the requirements of the skill and formulate a tentative plan of action. The learner must understand the goal of the activity and must be able to recognize and interpret the characteristics of the environment to which the movement must be matched. Based on the goal of the activity, the environmental constraints, and past movement experiences, the learner decides upon a plan of action and organizes a corresponding sequence of movement. The new plan, or motor schema, consists of a unique grouping of previously-learned sequences of movement (subroutines) and constitutes the learner's "best approximation" of a response that will lead to goal-attainment. Following a trial execution of the response, the learner monitors relevant feedback information, evaluates the effectiveness of the motor plan, and decides whether to repeat the response or alter it on the next trial. For both closed and open skills the initial stage of learning involves similar processes; the learner repeats the information-processing cycle until success (goal-attainment) in the initial performance context is achieved.

Later Stage(s) of Learning

During the subsequent stage of learning, the learner attempts to refine the motor schema and gain consistency in goal-attainment. Inappropriate or unnecessary subroutines must be eliminated from the sequence of movement. New subroutines are formulated, practiced, and integrated within the response, as necessary. Errors in sequencing are corrected and the timing of the movement is smoothed. Perceptual and decision processes are refined; the learner gains the ability to recognize patterns of environmental events, predict the nature of future events, and prime the responses most likely to be used in a given situation.

The objective of this extended practice phase is to gain consistency in goal-attainment. The development of skill in closed activities is less complex in terms of processing variables, although not necessarily easier, than is the case for open activities. Since performance occurs in a stable, constant environment for closed skills, the learner attempts to progressively narrow the range of variability in the movement response. The fixation of a successful movement pattern should lead to a high degree of consistency in goal-attainment for skills performed in an invariant environment.

For open skills, at the completion of the initial stage of learning the learner has developed a pattern of movement leading to success in goal-attainment in one, or perhaps several, of the variable contexts of

performance. During subsequent stages of learning, the learner must develop a motor schema capable of generating movement responses to match the characteristics of all possible environmental contexts for performance. In order to achieve skill, to consistently attain the performance goal, the learner must develop many diversified patterns of movement.

As a result of extended practice, the learner gains the ability to order and execute longer sequences of movement, and the organization and control of movement require less consious attention. Therefore, the learner's attention can be directed to other aspects of performance such as analysis of the preparatory movements of the opponent and positioning of teammates, execution of a secondary task, and/or consideration of the overall strategy of the game.

Teacher Responsibilities: Initial Stage of Learning

Identify Goal and Environmental Constraints

The goal of the activity must be made clear, if the learner is to plan a means, a pattern of movement, that will be successful in attaining that goal (Gentile, 1972). In some activities the overall goal of the skill is readily apparent to most learners; for example, put the ball in the basket, catch the frisbee, hit the ball. However, many games also have subgoals that are related to the component skills of the activity and contribute to accomplishing the overall goal. For example, the overall goal of badminton is to hit the shuttlecock in such a way that the opponent is unable to return it. However, the purpose of a clear in badminton is quite different, although contributing to the overall goal of the activity. The goal of a clear is to move the opponent to the back of the court and force a weak return, so that the subsequent attacking stroke cannot be returned by the opponent (Marteniuk, 1976). The teacher must not only clarify the overall goal of the activity, but must also ensure that the subgoals of the component skills of the activity, and their relationship to the overall goal of the game, are clear to the learner. If the hierarchy of goals is not clear to the learner, it is unlikely that effective plans of action will be formulated.

In addition to clarifying the goal of performance, the teacher must also identify the environmental constraints imposed on movement by the particular performance situation, and the general characteristics of an effective response. To formulate an effective plan of action, the learner must consider both the goal of performance and the nature of environmental constraints. Formation of a tentative plan of action based on past movement experiences may be facilitated by a general description/demonstration of an effective sequence of movement by the teacher. However, both environmental and movement information should be provided in very general terms at this stage of learning. The learner has not yet attempted the skill and, therefore, has no concrete frame of reference for detailed information concerning either environmental cues or movement characteristics. Detailed information regarding environmental and biomechanical

Detailed information regarding environmental and biomechanical constraints on movement should be given later, after the learner has developed a general idea of a successful response.

The importance of the teacher's role in clarifying the goal of performance and the constraints on movement cannot be over-emphasized. Too often, components of a skill, such as the tennis grip or the field hockey dribble, are presented to the learner in isolation, with no reference to the relationship between the subskill and the overall goal of the activity. Too often, the goal of performance is either presented by the teacher or perceived by the learner as moving in a particular stylized way, as conforming to a model of movement. Only in activities such as diving, figuring-skating, and dance is the goal of performance to produce a particular prescribed movement form. In all other cases, the particular movement employed is simply a means to an end. That is, success in performance must be judged in terms of the degree of goal-attainment achieved; a pattern of movement is judged "good" or "appropriate" on the basis of its effectiveness in terms of the goal of the activity, not in terms of its conformity to a traditional imposed style of movement. Simply naming the activity and demonstrating the first subskill to be learned is not sufficient input for goal-directed learning. Fitts (1964) has labelled the initial stage of learning the Cognitive Phase in an attempt to emphasize the importance of insuring that the learner understands the performance task. The teacher should clearly define the movement problem by accurately identifying the goal of performance and the constraints imposed on the movement response.

Structure Environment

The environmental conditions under which a learner practices a motor skill must be appropriate in terms of the actual environmental constraints which govern successful performance (Gentile, 1972). The teacher must deliberately structure the practice conditions in relation to the characteristics of the task and the skill level of the learner. Decisions regarding practice conditions must not be based simply on administrative/organizational considerations. The teacher must simplify the environment for practice to keep the information load within the processing capacity of the beginner, while also providing a realistic practice situation in terms of the environmental constraints on performance.

The task of structuring a simplified, yet realistic, environment for practice is somewhat easier for closed skills than for open skills, since the performance environment is stable and involves few variations. However, the teacher must carefully structure an appropriate set of stable, consistent environmental conditions for practice. The most important constant environmental characteristic should be emphasized during the initial stage of learning. Further, the teacher may decide to highlight critical features of the environment. For example, using a colored target or a colored ball, or placing spots on the basketball backboard or bowling alley, serves to enhance the important aspects of the performance context and direct the learner's attention to relevant environmental cues. The teacher may also

reduce the number of irrelevant, or non-constraining, stimulus events in the environment in an attempt to simplify the processing task for the learner. However, adding the normally-occurring, yet irrelevant, cues to the environment at a later time will introduce novelty into the performance environment, and may disrupt performance (Gentile, 1972). For example, the learner may initially practice the basketball free-throw without the presence of other players at either side of the lane. However, when performance must subsequently occur under competitive conditions that include the presence of other players, the learner may inappropriately attend to their movements and/or comments, with a resultant decrement in performance. The critical factor in structuring the environment for closed skills is provision for practice in an appropriate stable context including realistic environmental constraints. If the skill to be learned is target archery, then the practice environment must include a target, bow, and arrows. The task for the learner is to develop an adaptive movement involving body stability and object manipulation that will successfully project an arrow the necessary distance at the appropriate height. Mimetic practice without equipment will be of little or no benefit in facilitating the learner's problem-solving efforts.

Open skills must be practiced under variable environmental conditions; provision must be made for realistic practice involving moving objects or players if the learner is to truly develop skill in an open situation. The task for the teacher is to simplify the complex open environment of basketball, football, or field hockey, for example, while still maintaining the requisite "openness" of practice conditions. An open environment may be simplified by reducing the area in which performance occurs, reducing the number of players, limiting the number of environmental variations and subsequent response options, or slowing the speed of environmental events. The teacher may use one of several strategies in structuring practice conditions for the learner's initial performance trials. For example, the selected practice situation may be one providing for greatest early success or for maximum transfer to subsequent situations (Gentile, 1972). However, little conclusive information is available regarding the open practice conditions that are "easiest" for a given type of learner, or that will result in positive transfer. A third strategy for structuring practice is to select the environmental situation that occurs most often in game play (Gentile, 1972). Practice under the most commonly-occuring performance situation will probably involve conditions which are moderately difficult and will likely result in some positive transfer to other situations. The use of mini-game situations to provide simplified, yet realistic practice conditions for open skills such as team sports will be illustrated later in the chapter.

The critical factor in structuring the practice situation for open skills is provision for realistic movement of objects and people in the environment. If the skill to be learned involves complex perceptual and effector processes, the teacher may reduce the information load on one of the processes so that the other can be performed successfully by the beginner (Marteniuk, 1976). Once the learner has successfully completed one process several times, the second component of performance can be added and

both performed simultaneously. For example, the teacher may have beginners in tennis practice the volley in a simulated situation in which the ball is tossed to the racket from close range. In this way, the learner can attend almost exclusively to the organization and execution of the stroke. Once the general pattern of movement has been completed successfully, the learner can be put into a game situation in which complex perceptual and decision processes must be conducted relative to selective use of the volley. By allowing the learner became somewhat familiar with the sequence of movement for the volley, the uncertainty or information load is decreased. Therefore, when the learner enters the game situation, the execution of the skill will require less attention, thus freeing some of the processing system to deal with the perceptual and decision requirements of performance (Marteniuk, 1976).

In contrast to the technique suggested above, teachers frequently simplify the practice environment for open skills by inappropriately transforming them into closed skills. In teaching the skill of baseball batting, it is not uncommon for the initial practice situation to include the use of a stationary ball on a batting tee (closed environment). The use of a batting tee may facilitate the development of a "level swing", characterized by an appropriate stance, weight shift, full arm extension, wrist snap, and the like. However, the use of a stationary ball precludes the development of anticipatory skills, as well as the essential timing and spatial adaptation of the swing to the actual characteristics of ball flight. An appropriate practice environment for batting must include a pitched or projected ball, a batter's box, and a plate. The environment may be simplified by reducing both the speed and the variability of ball flight, thereby reducing the processing demands on the beginner while retaining a realistic, open situation for practice.

Direct Attention

Clarifying the goal of the activity for the learner and establishing the environment for practice does not insure that the learner will attend to the specific characteristics of the environment which dictate the nature of a successful response. The teacher cannot simply assume, for example, that the beginner will focus attention on the characteristics of the ball in tennis, no matter how "obvious" the need for monitoring ball flight may seem to be. During the performance of most motor skills, the performer is confronted with a large amount of information, and the teacher must help the learner distinguish between relevant and irrelevant sources of information. Through instructions and demonstrations, the teacher must direct the learner's attention to characteristics of the practice environment that define the characteristics of a successful pattern of movement (Whiting, 1969). In addition, the teacher must restrict the total number of events to which the beginner's attention is directed. That is, the teacher must select the environmental cues of most relevance for the beginner and direct the learner's attention to them. If the number of cues is not restricted, the

learner will selectively attend to a few events and will ignore the rest, possibly including the primary cue for successful performance.

For closed skills, the critical stimuli are present and unchanging in the environment; the teacher must simply direct the learner's attention to the most relevant cues. For example, the beginning bowler may be directed to focus on either the 1-3 pocket or on a particular alley "spot". The teacher may verbally identify relevant and irrelevant features of the environment (direct command), ask the student to identify the environmental constraints (guided discovery), or structure a problem-solving situation (Mosston, 1966). Whatever the style of presentation, the teacher must assume responsibility for facilitating the recognition of environmental constraints by the learner. For closed skills, the teacher is essentially providing instruction in simple orienting movements.

For open skills, the learner's attention must be directed to the variable environmental characteristics to which the movement response must be matched. Often, the relevant cues are not present in the environment during the teacher's explanation, but will occur later as the learner attempts an initial response (e.g., pitched ball). Further, during initial attempts at the activity, the learner may be unable to attend to both the movement response and the environmental cues. Therefore, one method of facilitating the process of selective attention to relevant information is to permit the learner to observe environmental events without responding (Gentile, 1972). For example, in learning batting skills, the performer may stand at the plate and simply watch as several pitches are delivered. This procedure enables the learner to assess the environmental characteristics to which the swing must conform, including the trial-to-trial variation in ball speed, direction, and the like. The teacher may also identify cues which will aid the learner in prediction and anticipation of ball flight. Although the suggested procedure artificially dichotomizes the processes of perception and movement organization, it reduces the initial load on the learner's information-processing system. The teacher must remember that everything is new to the beginner. The learner cannot yet distinguish between relevant and irrelevant information. The learner cannot simultaneously observe a visual demonstration, process verbal instructions, select a motor plan, organize a movement, and execute a response - all within the time-constraints of an open environment. The teacher can reduce the information load by not talking and demonstrating simultaneously, and by providing several initial "trials" for which the response is eliminated.

In some cases, it may be helpful for the teacher to provide specific instruction in orienting movements. For example, it may be necessary to show the learner the appropriate defensive position in basketball for obtaining information from the positioning of other players. Further, it may be necessary to direct the learner to ignore irrelevant information in the environment, such as fakes by the basketball opponent or deceptive preliminary movements of a pitcher (Whiting, 1969). The importance of directing the learner's attention to critical environmental cues cannot be overemphasized; the selection of appropriate input information is clearly essential

to the effectiveness of the total information-processing system and thus to successful performance.

Assist in Movement Organization

Once the teacher has clarified the goal of the activity to be learned, has structured the practice environment, and has directed the learner's attention to relevant cues in the environment, the preparations for the learner's first performance attempt are complete. Now the primary role in the teaching/learning situation is assumed by the learner (Gentile, 1972). The learner must draw upon past movement experiences to formulate a plan of action. A sequence of movement must be organized that is consonant with the learner's unique physiological and morphological characteristics, as well as appropriate to the goal of the activity and the environmental constraints on performance. The teacher should not, and indeed cannot, prescribe a movement pattern that will be both efficient and effective for all students. However, teachers have traditionally focused the bulk of their teaching efforts on descriptions and demonstrations of the desired pattern of response. Not only does such a procedure ignore individual differences and negate the concept of the learner as a problem-solving processor of information, it also assumes the inability of the learner to respond without guidance. Most students possess innumerable models of movement gained from exposure to motor skills through the mass media. They also have been solving motor problems and learning motor skills throughout their lifetime, neither assisted nor impeded by a teacher. The formulation and organization of a trial response is an individual task, the responsibility for which is the learner's, not the teacher's. The teacher's role must be restricted to assisting the learner in the organization of movement, as necessary.

The teacher may assist the learner in movement organization by suggesting the strategy of drawing on past movement experiences to form a general plan or idea of an effective sequence of movement in the particular situation. The teacher may describe the new activity in terms of sequences of movement already acquired by the learner. If the learner can recognize the similarity between already-acquired skills and the new skill, the formation of a plan of action for the new activity may be facilitated (Marteniuk, 1976). For example, the teacher may compare the action of the backswing and forward swing in the tennis serve to throwing a ball. Since throwing is familiar to most individuals, the general organizational concept of the movement may be transferred to the new skill. Indeed, in teaching the tennis serve, overhand throwing from the baseline to the service court is frequently used as a lead-up activity. The intent of the throwing drill is to provide a "review" of a relatively familiar pattern of movement, the general idea of which can serve as a basis for organizing the more complex sequence of movement for the tennis serve. Through description, demonstration, or lead-up activities, the teacher may assist the learner in transferring both general organizational concepts and specific subroutines of movement from already-learned activities to the initial attempt at the new

activity. During the later stage of learning, the preliminary plan of action will be adapted to incorporate the specific parameters of movement required by the new activity; during the initial stage of learning, a broad, general plan of action is both sufficient and appropriate to the processing-capacities of the beginner. The primary role of the teacher at this pre-response stage of learning is to instruct the student to use the available information to plan a movement, to think about the movement as it is performed, and to be prepared to evaluate the movement after the response is completed (Gentile, 1972; Skinner, 1972).

Monitor Response

Following the organization of a sequence of movement, the learner executes the first response in the learning situation. The teacher's role during the student response is that of a skilled observer of movement, preferably a silent observer. By observing the trial response, the teacher can subsequently provide augmented feedback to the learner, if necessary, during the process of response evaluation. Thus, during the execution of the response, the teacher should observe the degree to which the performance goal was attained and the characteristics of the movement sequence as executed. Following the response, the learner should be provided a brief opportunity to consolidate the intrinsic feedback from the response, prior to the presentation of the teacher's observations concerning the response (Gentile, 1972).

Provide Augmented Feedback and Assist in Decision-Making

Following the initial attempt at the new activity, the learner must use feedback to evaluate the effectiveness of the response. The task for the learner is to decide whether to alter the response or repeat it. To make this decision, the learner must determine whether (a) the movement was executed as planned and (b) whether the performance goal was accomplished (Gentile, 1972). The extent to which the movement was executed as planned is determined by comparing the plan of action with feedback concerning the characteristics of the movement as executed. Goal-accomplishment is evaluated by comparing the intent of the movement with feedback regarding the outcome of the response. The result of the evaluation process should be a modification of the original plan of action and/or goal in an attempt to achieve success on the next response trial (Marteniuk, 1976). Through repeated attempts, each followed by evaluation and modification, the movement will become increasingly effective.

In evaluating the initial response, the learner uses both feedback intrinsic to performance and information supplied by the teacher (augmented feedback). Clearly, the teacher cannot determine whether the learner was successful in executing the movement as planned. The teacher has simply observed the characteristics of the response; the learner must decide the extent to which a plan-movement match was achieved. However, the

beginning performer often is unaware of the specific nature of the response (Gentile, 1972). The learner's limited information-processing capacity may have been occupied in monitoring the coordination of the neuromuscular system as it executed an unfamiliar sequence of movement; the learner may have been unable to monitor feedback concerning the specific characteristics of the movement (Marteniuk, 1976). The teacher can facilitate the decision regarding execution of the movement plan by describing or demonstrating how the learner moved, or by showing the learner a videotape record of performance. If the learner forgot the response plan, the teacher may suggest responding again, after first verbalizing the plan of movement (Gentile, 1972).

The learner usually requires less augmented information to evaluate the outcome of the response. For the majority of motor skills, visual feedback concerning goal-attainment is readily available; the learner can see if the puck went into the goal or if the arrow hit the target. However, the teacher should be prepared to supply additional information, if necessary, concerning the precise nature of the response outcome, including the degree to which the goal was attained. For the limited group of motor skills requiring execution of a prescribed sequence of movement, it may be necessary for the teacher to supply precise information concerning the characteristics of movement in order to facilitate the outcome-goal comparison. In all cases, the teacher serves in an advisory capacity in the decision-making process, supplying supplementary feedback and suggesting strategies of response revision, if necessary.

The specific nature of the teacher's suggestions concerning response revision depends upon the results of the evaluation of the response by the learner (assisted by the teacher). If the movement was executed as planned and the performance goal was accomplished, the learner should be instructed to retain the same plan of action for use when the particular performance situation occurs again. If, in the view of the learner, the movement was successfully executed but the performance goal was not attained, the teacher should help the learner identify the source of error in movement organization. The learner may have failed to identify and/or consider the environmental constraints when organizing the sequence of movement (e.g., swing was too high or too slow relative to ball flight). Perhaps the learner failed to consider relevant biomechanical principles in organizing the components of response (e.g., racket face was too open or too closed at contact with ball). Once the source of error is identified, the learner may be able to correct the plan of action on the next attempt at the activity.

The evaluation of the initial response may produce two additional sets of results. The learner may conclude that the movement was not executed as planned, although the performance goal was accomplished. In this case, the teacher can help the learner analyze the characteristics of the unplanned yet successful response, so that the learner can attempt to duplicate the sequence of movement on the next performance trial. An alternative strategy is to suggest that the learner try to execute the original plan of movement on the next trial at the activity, to permit a more systematic analysis

and evaluation of performance. Finally, the results of the evaluation of the initial response may indicate that the learner failed to execute the movement as planned and also failed to attain the goal of performance. In this instance, the teacher should review both the goal of the activity and the environmental constraints on performance, and encourage the learner to try the plan of movement again. If the learner experiences repeated failure at executing the plan of action, it may be necessary to further simplify the practice environment (e.g., toss the tennis ball to the learner instead of hitting it), or to simplify the suggested sequence of movement (e.g., begin in a side-to-net position with racket back, instead of in the "ready" position in tennis). In addition, it may be necessary to alter the performance goal, if the learner repeatedly experiences failure (e.g., hit the ball over the net from the service line instead of from the baseline in tennis).

In summary, during the initial stage of learning, the emphasis in teaching should be to help the learner gain an understanding of the goal of the activity, the nature of environmental constraints on performance, and the characteristics of a successful pattern of movement. Instruction should focus on the most critical elements of performance, information should be kept general in nature, and transfer of perceptual and motor abilities from previously-learned skills should be encouraged. Once the learner is generally able to accomplish the goal of the activity by executing a planned sequence of movement, the initial stage of learning for both open and closed skills is completed.

Teacher Responsibilities: Late Stage(s) of Learning

The later stage of learning involves development of consistent goal-attainment through repeated performance of the task. During this second phase of learning, the teacher must gradually increase the amount of information presented to the learner. More complex cues relative to both the internal and external environment must be introduced, and emphasis must be placed on perceptual and decision processes, as well as on the organization and control of movement. The two major responsibilities of the teacher during the later stages of learning are structuring the environment for continued practice and providing augmented feedback (Gentile, 1972). Since the processing requirements for consistently successful performance differ for closed and open skills, the specific nature of the teacher's role in later learning also differs for the two types of activities.

Structure Environment

The teacher must gradually and systematically introduce into the practice situation, environmental cues that were eliminated during the first stage of learning to reduce the initial information-processing demand on the learner. For closed skills, practice should continue in a stable, consistent environment. The major responsibility of the teacher is to insure that the conditions under which the skill is practiced match those under which actual

performance will occur (Gentile, 1972). For example, if shot put competition will occur both indoors and outdoors, the performer must practice under both sets of environmental constraints. In this case, the performer must essentially develop skill in two distinct, although closely-related, activities: the indoor and outdoor shot put. The teacher must consider organismic as well as environmental variables in structuring practice. For example, practice of basketball free-throws should occur following a period of running, as is usually the case during competition. In addition, for the practice structure to match game conditions, the number of practice trials should be limited and the free-throw attempts should occur under a time limit. In order for the learner to assess the environmental constraints on performance and develop consistency in a sequence of movement matched to those demands, the teacher must include in the practice situation all environmental factors which regulate performance of a closed skill.

For open skills, as complexity is added to the practice environment it begins to more closely resemble the actual environment in which skilled performance occurs. During practice, emphasis must be placed on learning to interpret perceptual cues and on developing the ability to anticipate or predict the future state of the environment, due to the time stress under which open skills are performed. Since an open skill involves many possible environmental situations and, therefore, many variations in movement responses, the learner must also develop the ability to make quick and accurate decisions concerning alternative plans of action. The decision process can be facilitated by emphasizing the development of "stimulus-response" pairings. That is, the teacher must help the learner perceive the relationship between specific environmental demands and the specific plan of action that will best meet those demands. The most obvious means of developing a repertoire of situation-movement pairings is to practice in a gamelike situation in which all possible sets of environmental constraints are present, and all variations in particular patterns of movement are required. In addition, the teacher can facilitate the decision process by verbally describing the various situation-response combinations involved in the activity. Films can be used to illustrate specific environmental situations and the appropriate responses. In this case, films are used not to demonstrate ideal techniques of movement, but to illustrate the relationship between environmental situations and appropriate responses. The teacher can also encourage the learner to practice decision-making while observing a game situation. The appropriateness of the choice of action can be evaluated as the game situation unfolds.

If irrelevant features of the environment were excluded from the practice situation during the initial stage of learning, they should be systematically introduced into the performance context during later stages of learning. The noise of a crowd and comments from opponents are sources of irrelevant and potentially distracting cues in the environment for both open and closed skills. In addition, fakes by the opponent and incidental comments from teammates are additional sources of irrelevant information in the environment for open skills. Performers must learn to ignore irrelevant

environmental information in much the same way as they learn to selectively attend to relevant cues. Therefore, the teacher must systematically include irrelevant events in the environment during learning.

In learning an open skill, the performer must develop the ability to evaluate the variety of spatial and temporal characteristics present during performance and match each situation with an appropriate sequence of movement. Therefore, it would seem that practice should involve exposure of the learner to as many environmental situations as possible. For, example, once the learner has experienced initial success in the volleyball spike, it is essential that practice include an opponent attempting to block the spike. The presence of an opponent will require the learner to organize the timing and placement of the spike in accord with the opponent's actions. Thus, during the later stages of learning an open skill, practice should occur in gamelike situations as much as possible.

Provide Mini-Game Practice

One method of structuring realistic practice for open skills is to employ mini-game practice situations. The mini-game technique of structuring practice consists of repeated exposure to the game being learned, rather than presentation of a fixed sequence of component skills culminating in game play late in the learning process. Mini-game practice involves a repeating cycle of game play, identification of an area of skill deficiency, mini-game practice drills, and application of the skill in game play. To illustrate the cyclical nature of this game-oriented approach, the remainder of this section will describe how the technique might be applied to the teaching of field hockey.

Instruction should begin with an explanation of the essential nature or purpose of the game; simply stated, to cooperatively move the ball down the field and propell it across the goal line to score, while attempting to prevent the opposing team from scoring. Next, the teacher must clearly specify the rules which will govern initial game play, with particular emphasis on those related to players' safety; for example, field hockey rules prohibit raising the stick above shoulder height, hitting the ball directly into another player, and the like. If desirable, the teacher may impose additional "temporary rules" such as restricting the number of individuals who may simultaneously attempt to play the ball to two, and so forth.

Following the initial explanations, game play begins. The teacher assumes the role of careful and analytical observer. As game play continues, one of several game-related "problems" reflecting skill deficiencies will soon become apparent, to both players and teacher. For example, players may be quite successful in moving the ball toward the goal; the problem is that opposing players are unable to stop the offensive team. The teacher now stops the game and briefly verifies the nature of the problem with players. Subsequently, a mini-game drill is conducted to provide the learner with systematic, controlled practice of tackling skills. The mini-game simulates a game situation involving, for example, two offensive and two defensive players. By reducing the number of players, limiting the

playing area, slowing the action, and providing for repetition, the environment for practice of the defensive skill is simplified. By including both offensive and defensive players in game-related positions, the essential character of the game is retained during the mini-game practice.

Conversely, the game "problem" may be that players are unsuccessful in moving the ball toward the goal; the ball is consistently taken away from offensive players or intercepted. Following discussion of the problem, the teacher in this case structures a mini-game drill involving, for example, the straight dribble and diagonal pass to the left, again with two or more offensive and defensive players. Mini-games do not involve lines of players, each of whom executes an isolated skill in turn. Rather, the drills must involve game-like relationships in player-positioning, cooperative effort between team mates, and adaptation of the general skill as dictated by the specific actions of both offensive and defensive players during each trial situation.

In both of the situations illustrated, considerable practice would be provided in the mini-game format, with the teacher providing situationally-specific feedback regarding response options and execution. Following the mini-game practice, the specific skill is once again applied within the game context, either in a full-field or a half-field game. The essential element is to provide the opportunity for learners to experience a realistic playing situation and observe the effect of their decisions and subsequent movement responses.

In structuring future mini-game drills for the same general skill, the teacher should gradually increase the complexity of the practice situation by increasing the number of players and the speed of movement. In addition, the number of response options is also increased. For example, the lunge may be added to the straight tackle as defensive options; the pass to the right may be added to the pass to the left to increase offensive options. In each case, game play precedes and follows mini-game practice. The need for practice of additional skills such as dodge, drive, and the like, will arise from game play as the unit progresses.

The suggested game-oriented approach provides several clear benefits in terms of a positive learning environment. Student motivation will be increased through the game participation. Second, immediate game experience can provide the learners with a realistic frame of reference for the learning of component game skills. Once the relationship between fundamental skills and their adaptive use in game play is established (perhaps midway through the unit), isolated practice of individual skills becomes both beneficial and meaningful. The students then understand the need for the temporary artificiality of the situation in order to isolate practice on their specific deficiency in game-playing ability.

A critical element in this approach to teaching is the provision of feedback to the student relative to the effectiveness of responses. Corrections in technique, such as body and limb position, grip, weight shift, and the like, should be related to the effectiveness of the movement in a specific situation. Such corrections become more meaningful when the learner has

experienced the relative success/failure of movement technique in the game.

Teaching through the game requires both analytical skill and flexibility on the part of the teacher. Learning progressions, although predictable, are not completely predetermined. The nature of practice and drill structures evolves from game-related problems as identified by the teacher. Instruction must focus not only on technique of movement, but also on "reading" game cues, on assessing the performance situation, selecting a response, and executing the movement in the appropriate place at the optimum time. Similarly, feedback must relate not only to movement execution, but also to the effect of the response in the particular situation. Situational variety must be systematically introduced (for example, optional positioning of offensive and defensive players in a given situation); response options and their potential consequences must be clearly identified (for example, dodge vs. pass); and situationally-adapted patterns of movement must be demonstrated, practiced, and corrected. New skills are introduced on a priority basis, as the need for them arises in game play, and thus become clearly related to and integrated with previously learned skills. In all cases, the goal for the learner is to adapt movement responses to the demands of a particular situation. By teaching through the game, the students will develop the perceptual, decision, and movement abilities required to truly play the game.

This cyclical, game-oriented practice structure for open tasks has a number of advantages: (a) the practice occurs under appropriately variable environmental conditions, (b) the practice of subskills occurs in a natural progression, dependent upon the particular needs of the learner, (c) the need for and relevance of specific practice is immediately clear to both the teacher and the learner, (d) the use of isolated, artificial "skill drills" is eliminated, and (e) the progress made in development of skill in the actual activity is apparent to both teacher and learner.

Lessons for open skills should not be planned in terms of movement; for example, two weeks of forehand, two weeks of backhand, and one week of serving in tennis. Rather, the teacher should plan in terms of environmental situations; for example, baseline strokes, net play, and midcourt techniques in tennis. Diversification of movement will not occur if the learner repeatedly practices one shot or one stroke in one situation for long periods of time. Therefore, whatever the selected strategy for structuring practice of open skills, the teacher must assume the responsibility for providing systematic variation in the performance environment.

Direct Attention

As practice continues during the later stages of learning, the teacher should provide more specific cues to the learner regarding the focus of attention before, during and after performance. For closed skills, the learner's attention should be directed toward the internal environment; toward movement-produced cues regarding body and limb position, force parameters, spatial orientation, and the like, in order to facilitate

development of a consistent pattern of movement (Knapp, 1963). For an open skill, the learner's attention should be directed toward the external environment, toward changing events to which the characteristics of movement patterns must conform (Gentile, 1972). The open skill performer must learn the probability of occurance of events in the environment in order to predict, plan ahead, and rapidly select an appropriate response. The learner cannot develop anticipatory skills by batting a stationary ball from a batting tee, or by participating in long hours of tennis-swing mimetics without reference to court, opponent, or moving ball. Providing a variable practice environment for open skills is necessary for the attainment of requisite perceptual and decision processes, as well as for the development of appropriate responses.

Provide Augmented Feedback

One of the major responsibilities of the teacher during the later stages of learning is the provision of augmented feedback. The performer of closed activities is attempting to develop consistency in executing a response that is successful in goal-attainment. Knapp (1963) has suggested that the learner develops a mental model of an effective plan of movement. Subsequently, the learner attempts to repeat the movement as planned., evaluate the degree to which a movement-model match was attained, and modify the next response in order to gain greater conformity with the model performance. As was the case for the initial stage of learning, the teacher can facilitate this process by providing specific augmented information to the learner regarding characteristics of the response (DelRay, 1972). In particular, the teacher should identify sources of variability in the pattern of movement for non-successful trials. The teacher may describe the movement or illustrate the response via videotape replay or a polaroid, graph-check-sequence photograph. The critical feature of information-processing at this stage of learning is the attempt to achieve a consistent match between the learner's model of successful performance and the response as executed.

During early stages of learning for both open and closed skills, the performer relies primarily on information from the external environment, particularly visual feedback, to guide and modify movement (Robb, 1968). As skill develops, kinesthetic/proprioceptive information plays an increasing role in movement guidance for closed tasks (Fleishman and Rich, 1968). A performer who is limited in the ability to use kinesthetic/proprioceptive feedback is also limited in the level of skill that can be attained in closed activities at advanced levels of practice (Knapp, 1963). Therefore, the teacher must not only augment information regarding characteristics of movement, but also help the learner attend to and use intrinsic sources of information regarding the characteristics of responses.

During the later stages of learning, the open skill performer is attempting to diversify responses, to develop sequences of movement to match the variety of environmental events encountered during performance. Because of the time stress inherent in performance of open tasks, the learner is also

attempting to predict the occurence of environmental events in order to prime likely responses and select the most appropriate response for a given situation. The teacher can facilitate the learning process by supplying augmented information concerning the outcome of the movement response (Gentile, 1972). This augmented feedback should provide more detailed information concerning the degree of goal-attainment than is available from intrinsic sources of feedback. In addition, the teacher should supply information concerning the effect of the response on the performance environment; that is, changes occuring in the performance situation as a result of the learner's response.

One strategy for providing augmented feedback for open skills is to show the learner the state of the environment before, during, and after the response. For example, the teacher may restructure the basketball situation that prevailed at the time the offensive player passed the ball to an inappropriate area. Videotape replay may also be used to illustrate the relationship between the selected movement response and subsequent environmental events. More advanced learners may simply require a verbal description of the environmental situation and consequences of the response. Whatever the means employed to present information to the learner, the feedback should focus on the environmental conditions under which the response decisions were made and the subsequent effect of the responses on the environment. The purpose of augmented feedback is to help the learner recognize relevant events in the environment to which attention should have been directed, identify response alternatives that were available, characterize the response that occurred, and evaluate the consequences of both the selected response and the response alternatives. Augmented feedback concerning the degree to which movement was matched to prevailing environmental events will enable the learner to evaluate the selected response and rate its degree of effectiveness for future use in a similar situation. Consistent goal-attainment in open tasks requires not only the development of a repertoire of movements, but also the evaluation of the effectiveness of each response under the many sets of environmental conditions encountered during performance.

Developing Skill in Sport

What strategies of teaching will be most effective in in developing skill in sport? Decisions regarding teaching should be based on an analysis of the characteristics of the activity to be learned and the information-processing requirements for performance at a particular stage of learning. The demands placed on the learner by various types of sport skills differ considerably. Skilled performance of given task may require either body stability or body transport, often in combination with object manipulation, within either a stable or moving environment. To the extent that performance demands on the learner differ across categories of sport skills, the respective learning process also differs in the emphasis placed upon various

components of the information-processing system. A number of critical factors in the learning process vary as a function of the performance environment, including the nature of orienting movements, focus of attention, requirements for prediction, time available for response selection and execution, nature of movement organization, type of feedback, criteria for response evaluation, and degree of response consistency. If the requirements for performance of sport skills differ critically, and if the process of learning differs critically, then clearly closed and open tasks should be taught differently.

The performance of sport skills has been described as a series of information-processing tasks designed to produce a response matched to the demands of the performance situation. Identification of the component processes involved in the performance of sport skills suggests not only the sophistication and adaptability of the perceptual-motor system, but also the complexity of the learning process. Teaching strategies must provide for development and refinement of each of the perceptual, decision, and motor processes involved in performance. Unsuccessful performance at any stage of learning must be analyzed relative to an error in any one or more of the components of the information-processing system. Observing the pattern of movement displayed by the performer permits an evaluation of only one-third of the total processes involved in successful performance. Skill in sport depends upon the effective execution of many processes including environmental monitoring, perceptual analysis, decision-making, movement organization, and response control and coordination; an error in executing any one of the component processes can result in an ineffective pattern of movement.

The obvious key to facilitating the development of skill in sport is an understanding by the teacher of the nature of the particular activity to be learned and the process of learning. The teacher must clearly analyze the goal, environmental constraints, perceptual requirements, and desired response outcome for the activity to be learned. Only then is the teacher prepared to facilitate and evaluate the development of skill by the learner. The organization of the activity presentation, practice schedules, and drill exercises is heavily dependent upon the characteristics of the sport skill to be learned. For example, lessons for open activities should be planned in terms of environmental situations, rather than in terms of isolated, "fundamental" movement skills. For the majority of sport skills, the teacher's role should not consist of molding the learner's movement to fit a universal model of an "ideal" form or technique for performance. Rather, the teacher must assist the learner in attaining the actual goal of the activity-to put the ball in the basket, over the net, or down the alley.

It is essential that the teacher analyze sport skills, relative to both perceptual and motor requirements for successful performance. The role of the teacher is to help students "learn how to learn". To develop students' skill in sport, the teacher must structure a learning situation that will facilitate an active process of seeking successful solutions to relevant motor prob-

lems by matching movements to the characteristics of the performance environment.

Reference Notes

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